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ENVIRONMENTAL AND SOCIO-ECONOMIC SERVICES

MURPHY CREEK PROJECT ENVIRONMENTAL IMPACT EVALUATION: DOWNSTREAM WATER USE STUDY

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This impact assessment is based on the "Murphy Creek Project Engineering Description" prepared in November 1982. Since that time, ongoing planning and design studies have resulted in some changes that would affect the project description. The principal changes are as follows:

- In-service date has changed from 1993 to 1995.
- Installed capacity has changed from 300 MW to 275 MW.
- Small changes to the design and locations of shoreline protective works.
- Daily reservoir level fluctuations limited to 2.0 m during March, April and May (previously March and April).

The above changes have been incorporated in the report only where they would affect the results of the impact assessment.

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SYNOPSIS OF FINDINGS

This synopsis of the report has been included for the purpose of providing a capsule summary of the study findings.

Highlights of each report section are as follows:

Existing Water Supply Systems

1. Water supply systems located downstream of the Murphy Creek Project site are grouped as follows:
   - Cominco-Tadanac-Warfield
   - Trail
   - Oasis-Rivervale
   - Green Gables-Cutillo
   - Montrose-Beaver Falls-Fruitvale
2. The Cominco system is the only one that obtains water supply directly from the Columbia River, and it is the major water user in the region.
3. Cominco also provides supply to the communities of Tadanac and Warfield via two water filtration plants.
4. The major municipal waterworks system in the region is the one serving the City of Trail.
5. The Trail system is based on a combination of groundwater wells and surface supply from mountain lakes.

6. Systems based exclusively on groundwater supply include Montrose, Beaver Falls, Green Gables, Cutillo and Oasis.

7. Systems utilizing creeks for surface supply include Fruitvale and Rivervale.

Water User Concerns

8. For Cominco, the concern with respect to the impact of construction on the Columbia River is two-fold:

   - low water levels in the river could curtail plant operations

   - increased suspended sediment levels in the river at certain times during construction could impact on pumping and industrial process operations

9. For the Tadanac and Warfield water filtration plants, that increased turbidity in the river supply at certain times during construction could impact on the effectiveness of the treatment process.

Water Quality Impact

10. The maximum turbidity and suspended sediment levels on record occurred during construction of Hugh Keenleyside Dam.

11. Keenleyside was constructed "in the wet" using suction dredges that discharged silty material to the river, thereby creating turbid conditions downstream.

12. Impact on Cominco during construction of Keenleyside was apparently minimal, as the existing filters and process screens were reportedly able to handle the sediment loading.

13. Murphy Creek Dam, on the other hand, would be constructed "in the dry" behind cofferdams such that sediment discharges to the river would be minimized.

14. Impact on Cominco during construction of Murphy Creek Dam would be minimal, since turbidity and suspended sediment levels are likely to be significantly less than those recorded during construction of Keenleyside.

15. Any possible impact on Cominco could be avoided by curtailing construction activities should suspended sediment levels begin to approach a pre-determined critical level.

Population Impact

16. The population increase (of perhaps 600 people) likely to be generated by the Project is insignificant in comparison with the existing regional population (i.e. less than 0.5 percent).

17. The Trail waterworks system has surplus capacity and could provide for the above noted population increase.

18. The support capacities of other downstream waterworks systems are typically only marginally adequate for the existing population.

19. Based on experience with previous Hydro projects in the West Kootenays, the construction workforce would likely be dispersed throughout a number of communities such that there would be no concentrated impact on any one community.

20. Existing downstream wastewater treatment systems have surplus capacity to support any population increase likely to be generated by the Murphy Creek project.

Replacement of Community Water Supplies

21. Replacement water supply to Oasis-Rivervale could be provided by means of connections to a feedermain extension from the Tadanac Water Treatment Plant should this system supply B. C. Hydro's construction camp located near Rivervale.

FOREWORD REGARDING UNITS OF MEASUREMENT

The waterworks industry in British Columbia continues to be largely based on the Imperial system for volume measurement. This applies particularly to data on water usage and capacity ratings of water supply systems. In addition, metric conversions do not necessarily have a technical basis - for example, in North America pumps are still being manufactured in terms of "US gallons per minute"; while waterworks operators continue to measure pressure in "psi" units rather than "kilopascals".

For the purposes of this report, however, data are presented in terms of both Imperial and metric units of measurement.

PART A - INTRODUCTION & INVENTORY

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MURPHY CREEK PROJECT
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1. INTRODUCTION

1.1 Background

B. C. Hydro is currently preparing preliminary designs for a potential hydro-electric power plant on the Columbia River. The site is near Murphy Creek 3 km upstream of the City of Trail.

The Murphy Creek Project involves construction of a zoned earth-rock fill dam 28 metres above the river bed, and extending across the river from the east bank to a concrete spillway and 5-unit powerhouse located on the west bank. The proposed installed capacity of the powerplant is 300 MW. (Reference No. 1)

B. C. Hydro has commissioned a number of environmental studies for the potential project. The general objectives of these studies are identified in a document dated April 1981, and titled "Terms of Reference for Environmental Studies for the Proposed Murphy Creek Hydroelectric Project", and are as follows:

> 1. *Provide an inventory of environmental resources that could be impacted by the potential project within the study area. This will be compiled from on-site investigations and other available sources.*

2. *Provide a qualitative and quantitative evaluation of impacts, both adverse and beneficial, which would result from the potential project.*

3. *Provide an evaluation of resource losses and gains in monetary terms for inclusion in a benefit-cost analysis.*

4. *Provide an evaluation of opportunities for practical mitigation and compensation measures which would avoid or reduce adverse impacts created by the development.*

A copy of the Terms of Reference is included as Appendix 1.

Kerr Wood Leidal Associates Ltd. have been retained by letter dated March 6, 1981 to complete the assessment of the impact of the actual development and related activities on downstream waterworks systems during construction.

1.2 Scope of Assignment

The Terms of Reference referred to previously include the following guidelines for the "downstream water use" study:

INVENTORY

Carry out field investigations and office studies to provide an inventory of knowledge of existing Columbia River water users and tributary water users in those areas where project activities could occur (such as Hanna and Billy creeks), in the area between the proposed Murphy Creek Dam Site and the US/Canada border. This will cover but not be limited to:

1. *The number, type (description) and location of*

consumptive domestic, commercial, community water facilities users. This inventory will also determine those users/user facilities which are dependent upon existing river fed groundwater.

2. Data sources to be evaluated include municipal, provincial and the federal government agencies, regional districts and community/commercial concerns.

3. Document public and commercial concerns with respect to water use.

EFFECTS OF DEVELOPMENT

Make an assessment of the potential impact of the proposed development on the existing and potential downstream water users/user facilities below the Dam Site. (This does not include unregistered well systems.)

1. Recommendations should be made towards alternative mitigation/compensation measures which could entail preparation of alternative plans for water supply (either on an interim or permanent basis), preparation of capital cost estimates and a discussion of the strategies for implementation.

2. Quantitative data on water quality/quantity will be utilized wherever appropriate to the assessment of the effect of the development.

3. Assess public and commercial concerns with respect to the effect of the development.

The specific areas of study are as follows:

- the public health and operational implications for downstream water users as a result of a possible deterioration in water quality during the construction period

- the capability of existing systems to provide for increased water supply requirements as a result of population increase generated either directly or indirectly by the construction project

Although this study was initially concerned with downstream waterworks systems, B. C. Hydro subsequently expanded the scope to provide an overview with respect to possible impact on downstream wastewater systems, and upstream waterworks and wastewater systems. This overview was concerned specifically with the population impact on system capacities.

1.3 Study Area

The primary Study Area extends from the Murphy Creek damsite to the Canada/USA border as shown on Figure 1, and encompasses the following residential communities:

- City of Trail
- Tadanac (formerly a district, but now part of Trail)
- Village of Warfield
- Village of Montrose
- Oasis Waterworks District
- Fruitvale Waterworks District
- Beaver Falls Waterworks District
- Rivervale Water Company service area
- Green Gables Waterworks Utility Ltd. service area
- Cutillo Water Company service area

The Cominco Ltd. industrial complex, located in Trail, is the major consumer of water in the Study Area.

Upstream of the project site, the expanded Study Area encompasses Genelle-China Creek and the communities within the Castlegar Region (i.e. City of Castlegar, Balfour-Robson-Raspberry, Brilliant, Blueberry-Fairview, and Ootischenia).

1.4 Approach

The Study on downstream water use has been undertaken in three phases, generally as follows:

- Phase 1 - inventory of existing water supply systems located downstream of the proposed damsite, including documentation of water user concerns

- Phase 2 - assessment of the possible impacts of dam construction on existing and possible future systems

- Phase 3 - discussion of possible plans for alternative water supply, either on an interim or permanent basis, for communities that may be impacted by dam construction

Phase 1

The assignment was initiated by meeting with officials of the Regional District of Kootenay Boundary on March 5, 1981, since the District encompasses the Study Area. The purpose of the meeting was two-fold:

- to ascertain whether (and to what extent) the Regional District is involved in the operation of community waterworks systems

- to obtain mapping of the region

The next step was to contact the Water Management Branch of the Ministry of Environment in order to obtain a listing of all water licence holders located downstream of the project site. This listing provided the basis for subsequent field investigations, and is presented herein as Table 1.

A request was also submitted to the Groundwater Division of the Ministry of Environment for information on groundwater wells within the Study Area.

Letters of enquiry were also sent out as follows:

- to the West Kootenay Health Unit, for information on water quality

- to Cominco Ltd., to arrange a tour of Cominco's water supply system

The field investigation phase of the work commenced during the week of April 6, 1981 and was completed by the end of May, 1981. This generally involved making contact with the operators of waterworks systems, and then arranging for an inspection tour of the facilities.

The systems that were inspected first-hand were:

- Cominco
- Trail
- Rivervale
- Oasis
- Green Gables
- McGauley
- Waneta
- Montrose

TABLE 1

SUMMARY OF EXISTING WATER LICENCES ALONG THE COLUMBIA RIVER*

Licensee	No. of Licences
Village of Warfield	2
District of Tadanac	1
Cominco Ltd.	4
City of Trail	1
McGauley Ready Mix Ltd.	1
A & G Strobel (Waneta)	1

* Information provided by Water Management Branch, Ministry of Environment. Note that Water licences are not necessarily currently active.

It should be noted that Cominco provides water supply to both Tadanac and Warfield.

Information on the Beaver Creek Valley region (i.e. Montrose-Beaver Falls-Fruitvale-Cutillo) was obtained from a water study completed on behalf of the Ministry of Municipal Affairs in November 1980. (Reference No. 2)

The emphasis in the field investigation phase was on the Cominco and Trail systems as these are by far the most significant.

Phase 2

The focus in Phase 2 was on Cominco for two reasons:

- Cominco is the major user of Columbia River water
- Cominco expressed concern that construction activity could have an adverse impact on the Cominco operation if this activity resulted in a deterioration of water quality beyond a critical level

The water quality parameter identified as the key to the assessment was suspended sediment (i.e. sediment matter that is held in suspension by the water).

The assignment then involved resolving three issues:

- baseline (i.e. existing) levels of suspended sediment in the river under natural conditions (i.e. for the period since construction of the Hugh Keenleyside Dam)
- the extent to which the proposed method of diversion channel excavation and dam construction for the Murphy Creek Project

could generate suspended sediment

- the threshold (i.e. maximum) level of suspended sediment Cominco can tolerate without any noticeable impact on pumping and industrial process operations

In order to resolve these issues, International Environmental Consultants Ltd. were requested to provide background information on water quality (Ref. No. 3); B. C. Hydro was requested to provide quantitative information related to sediment transport (Ref. No. 4); and Cominco was requested to provide information on the implications of using turbid water in the process operations (Ref. No. 5).

Our task then became one of reconciling the various data inputs in order to assess the probability of occurrence of an impact; and in order to recommend appropriate mitigation measures.

Although the focus was on water quality as related to Cominco, the other area of concern was the "people impact" on the capacities of existing waterworks and wastewater systems. In this regard, the key issue is the extent to which the workforce might be settled off-site in existing communities, rather than on-site in a construction camp. Therefore, DPA Consulting Ltd. (who were responsible for the socio-economic impact analysis study) were requested to provide the relevant population data for those communities where it is anticipated that growth would most likely occur. (Ref. No. 6)

Our task, then, was to provide information on the capability of existing systems to support an increase in service population. This information was required in order to assess the relative significance of increased water supply and wastewater treatment requirements resulting from population growth generated directly or indirectly by the Project.

Phase 3

The third and final phase of the study involved a review of long-term plans for upgrading community systems in designated primary settlement areas (i.e. areas where population growth is to be directed in accordance with Regional Plans) that were developed independently of the Murphy Creek Project.

The objective was to provide B. C. Hydro with information for possible incorporation in the socio-economic component of the Murphy Creek planning process - specifically, the development of a population settlement strategy for settling in-migrant workers and/or re-settling people forced to relocate as a result of the Project.

Additionally, a conceptual plan was developed for supplying Cominco with water from an intake located upstream of the dam. The purpose was simply to provide B. C. Hydro with an order-of-magnitude cost estimate for a replacement system equivalent to the existing river intake and pump station.

The information presented in this report, however, relates to proposed mitigation measures for specific impacts (on existing waterworks systems) that are directly attributable to the Murphy Creek Project.

2. EXISTING WATER SUPPLY SYSTEMS

2.1 General

The relative locations of waterworks systems within the Study Area are indicated on Figure 2. For the purposes of a review, these systems have been grouped as follows:

- Cominco-Tadanac-Warfield
- Trail
- Oasis-Rivervale
- Green Gables - Cutillo
- Montrose-Beaver Falls-Fruitvale
- McGauley-Columbia Gardens-Waneta

In subsequent sub-sections, each of these systems is described briefly based on the best available reference information and the results of field investigations. This comprises the Phase 1 inventory as referred to in Section 1.4.

It is noteworthy that only Cominco (and therefore Tadanac and Warfield as well) obtains water supply directly from the Columbia River. With the exception of Rivervale and Fruitvale, all other community systems are based on groundwater supply. Trail is based on a combination of surface and groundwater.

2.2 Cominco-Tadanac-Warfield

A schematic of the Cominco water supply system is included as Figure 3. The primary facilities are as follows:

- the Stoney Creek Pumphouse
- the Flumehouse Reservoirs
- the Flumehouse Pump Station
- the Tadanac Water Treatment Plant (i.e."W.T.P.")

- the Warfield Headtanks
- the Warfield Water Treatment Plant
- the Warfield Reservoir

A brief description of the overall system operation is as follows:

- the Stoney Creek Pump Station incorporates a river intake structure for extracting water from the Columbia River

- the raw river water is first pumped through three supply mains to the Flumehouse Reservoirs, where the incoming flow is chlorinated

- Cominco's Tadanac Plants are then supplied by gravity from the reservoirs

- the Tadanac Water Treatment Plant is also supplied by gravity from the reservoirs

- the Tadanac W.T.P. then provides the domestic water supply for the Tadanac townsite and the bottling plant

- next, Cominco's Warfield Plants are supplied by pumping out of the Flumehouse Reservoirs to the Warfield Headtanks.

- the Headtanks then provide a gravity supply down to the Warfield Water Treatment Plant

- finally, the treated water is pumped to the Warfield Reservoir for supply to the Village of Warfield

- the Warfield Reservoir also allows for gravity supply of treated water to the boilers in the Warfield Plants and some drinking water in the plants

TABLE 2

SUMMARY OF PUMP DATA FOR STONEY CREEK PUMP STATION*

PUMP NO.	CAPACITY*		HORSEPOWER	COMMENTS
	(Igpm)	(Lpm)	(hp)	
1,2	**3000	13700	425	Operate continuously
3	3500	16000	475	Used to meet demand variations
4	3000	13700	425	Used to meet demand variations
5	3500	16000	475	Standby
6	8000	36400	1400	Standby
7	8000	36400	1250	Operates continuously
8	6000	27300	900	Operate continuously
9-11	8000**	36400	1400	Operate continuously

+ Data provided by Cominco.

* Pumps are rated in terms of Imperial gallons per minute (Igpm); metric conversion given in terms of litres per minute (Lpm) for comparison only.

** Capacity of each pump.

The system comprises two main pressure zones:

- the High Zone is established by the Warfield Reservoirs at a top water level (i.e. "TWL") corresponding to El. 650.76m (Geodetic), and encompasses the Warfield Plant's service area

- the Low Zone is established by the Flumehouse Reservoirs at a TWL corresponding to El. 501.56m (Geodetic), and encompasses the Tadanac Plant's service area

A third zone is that encompassed by the Tadanac townsite. This zone is established by a reservoir at the Tadanac W.T.P. that has a TWL corresponding to El. 498.25m (Geodetic), and a capacity of 0.56 megalitres (124,000 gallons).

Specific details concerning each of the primary facilities are summarized below:

- Stoney Creek Pump Station

  - there are eleven pumping units as listed in Table 2

  - individual suction header pipes (for each pump) extend a short distance horizontally into the river

  - each pipe is complete with a stainless steel inlet screen having 20mm openings

  - the inlet elevations are as follows:

NO.	ELEVATION (METRES) Geodetic	Cominco Datum
1-5	402.66	408.54
6-8	402.05	407.93 (centerline)
9-11	402.50	408.38 (centreline)

- the relationship between pump station operation and the water level in the Columbia River is summarized below:

READING ON STAFF GAUGE AT S.E. CORNER OF BUILDING (ft.)	GEODETIC DATUM (m)	OPERATING CONDITION
0	404.86	Absolute Minimum
2 - 3	405.47-405.79	Normal Minimum

- the river level required for 'satisfactory' pump operation (i.e. to provide minimum submergence) corresponds to about 0.5 ft. on the staff gauge

- this level corresponds to a 'minimum steady flow' of approximately 425cms (i.e. "cubic metres per second")

- the total pumping rate is typically in the order of 44000 gpm (i.e. equivalent to 3.4 cubic metres per second)

- the raw water is pumped through three pipelines as follows:

DIAMETER (mm)	TYPE	YEAR INSTALLED
750	Woodstave	1943
900	Steel	1957
750	Steel	1964

- Flumehouse Reservoirs
  - the total incoming flow is chlorinated in order to prevent algae growth in the piping system
  - the Chlorination application rate is normally in the range of 0.7 to 1.5 ppm (i.e. "parts per million")
  - this typically results in a chlorine residual in the range of 0.1 to 0.25 ppm
  - the chlorination system includes a residual analyzer and automatic controller
  - the chlorinated flow enters Reservoir No. 1 which has a storage capacity of 4.50 megalitres (1.0 million gallons)
  - No. 1 is connected to Reservoir No. 2 which has a capacity of 11.25 megalitres (2.5 MG)
  - both reservoirs are open top, and both function as settling tanks
  - water supply to the Tadanac Plants is by gravity from No. 2

  - water supply to the Tadanac Water Treatment Plant is by gravity from No. 1 via the Flumehouse Pump Station

- Flumehouse Pump Station

  - pumps out of Reservoir No. 1, through the Warfield Plants, and into the Warfield Headtanks

  - there are six pumping units as follows:

NO.	CAPACITY (Igpm)	CAPACITY (Lpm)	HORSEPOWER (hp)	COMMENTS
1,2	1500	6800	300	Used to meet demand variations
3	5500	25000	1250	Standby
4	5500	25000	1200	Standby
5	3000	13700	800	Operates continuously
6	6000	27300	1400	Operates continuously

  - the total pumping rate is typically in the order of 11-12000 gpm (50-55000 Lpm)

  - the chlorinated water is pumped via two pipelines (one 600 mm , and the other 750 mm) to the Warfield Plants; the pipelines are both reduced to 400 mm diameter through the plants

- Warfield Headtanks

  - Woodstave tanks, each with a capacity of 2.25 megalitres (0.5MG)

  - connected to the Warfield Plants by two 400 mm inlet-outlet mains
  - also connected to the Warfield Water Treatment Plant by a 250 mm main

- Warfield and Tadanac Water Treatment Plants
  - the treatment process consists of coagulation, sedimentation and filtration
  - the chemicals used for coagulation are alum (at 3.4ppm) and nalcolite 110A (at 0.3ppm)
  - the Tadanac Plant has a design capacity of 2.70 megalitres per day (600,000gpd) while the Warfield Plant has a capacity of 4.50 megalitres per day (1,000,000 gpd)
  - Tadanac has 4 sand filters; Warfield has 6 semi mixed-media filters
  - both plants were provided by B.C.Hydro in 1965 during construction of the Keenleyside Dam
  - treated water from the Tadanac W.T.P. is used in Cominco's bottling plant for filling drinking water coolers

- Warfield Reservoir
  - steel tank, with a capacity of 4.50 megalitres (1.0mg)
  - treated water is pumped into it from the Warfield W.T.P.
  - this water is primarily for domestic supply to the Village of Warfield

- a 300 mm main conveys the water to Warfield where it is then pumped to a buried reservoir at a higher elevation

- a 200 mm main provides for supply of the treated water to the Warfield Plants

- during periods of peak water usage in the summer, Cominco supplements the supply to the Village by about 25% by diverting untreated water that would otherwise be used in the Warfield Plants

Statistical information on water usage is as follows:

- the monthly average pumped out of the river is in the order of 9000 megalitres (2 billion gallons)

- of this amount, over one-quarter is pumped to the Warfield Plants

- seasonal variation is minimal

- approximately 97.5% is used in the industrial complex, with the remaining 2.5% used for domestic purposes in Tadanac and Warfield

- the average monthly volumes of water treated in the Tadanac and Warfield WTPs for the period 1978-80 were 17 megalitres (3.8 MG) and 100 megalitres (22.2 MG), respectively

2.3 Trail

A plan showing the location of the major water supply facilities in the City of Trail is included as Figure 4. This plan also indicates the relative locations of the Cominco-Warfield-Tadanac facilities.

The City presently obtains water supply from three sources as follows:

- Violin Lake and Cambridge Creek (i.e. a gravity source situated in the mountains due south of Trail)
- two groundwater wells in Sunningdale that are located on the east bank of the Columbia River
- a groundwater well located on McLean Street in East Trail.

Recently, the City developed a fourth groundwater well in Waneta on the north side of the Columbia River near the eastern boundary of the Municipality. At the time of writing, (1981), the well had not been integrated into the supply system.

The City also has a Water Licence for 11.25 megalitres per day (2.5MGD) on the Columbia River, and is proceeding with an application to increase this to 24.75 megalitres per day (5.5MGD).

The supply system includes three booster pump stations and seven water storage reservoirs.

A brief description of the system operation is as follows:

- a 300 mm supply main from an intake on Cambridge Creek conveys water from the Violin Lake source to the Coleman Street Reservoir in West Trail

- a 300 mm feeder main continues along Rossland Avenue and Victoria Street to the Columbia River Bridge where a booster pump station is located

- this main provides water supply to the lower part of West Trail

- the upper part of West Trail is supplied by booster pumping from Binns Street to the Lookout Street Reservoir

- the Lookout Street Reservoir then feeds the Gorge Creek Reservoir that is located at a lower elevation

- the 300 mm West Trail Feeder Main continues across the Columbia River Bridge and ties into the 400 mm East Trail Feeder Main

- the East Trail Feeder Main extends for the full length of the Municipality and progressively decreases in size as shown on Figure 4

- the feeder main supplies the Sunningdale, East Trail, Glenmerry and Waneta areas

- groundwater from the Sunningdale and McLean Street wells is pumped to the TWL of the Sunningdale and Glenmerry Reservoirs

Water supply to West Trail is exclusively from the Violin Lake-Cambridge Creek source, although the Victoria Street Booster Pump Station includes provision for pumping back from East Trail in an emergency.

Water supply to the areas across the river is based on a combination of groundwater and surface water as follows:

- during period of low demand, supply is from the Violin Lake-Cambridge Creek source
- as demand increases, water first starts to flow out of the Glenmerry Reservoir and then out of the Sunningdale Reservoir
- as demand continues to increase, the McLean Street and Sunningdale groundwater well pumping stations are activated, as are the Victoria Street and Rockland Avenue booster pumping stations

The City formerly had a pump station intake on the Columbia River. This was constructed in 1948 to supply East Trail, and was removed from active service in 1964 when B. C. Hydro provided the two replacement wells in Sunningdale. The pump station can be reactivated in the event of an emergency.

Specific details concerning the sources of supply are as follows:

- Violin Lake-Cambridge Creek system
  - the effective storage volumes for Violin Lake and Cambridge Lake have been estimated at 1080 megalitres (240MG) and 225 megalitres (50MG), respectively
  - the outlet supply main reportedly operates at full capacity during periods of peak summer demand
  - there is reportedly a water quality problem with respect to odour and taste

- Sunningdale Wells
  - constructed by B. C. Hydro in 1965 as a mitigation measure related to construction of the Keenleyside Dam
  - the pump stations were originally sized for 7600 Lpm (2000 US gpm), but the present capacities of Nos. 1 and 2 are reportedly 2100 and 1150 Lpm (i.e. 550 and 300 US gpm), respectively
  - the decline in the well yield began within the first year of operation
  - another problem has been that of iron bacteria
  - there have also been mechanical problems related to vibration of the deep shafts
  - the wells are drilled adjacent to the Columbia River, but their water quality is significantly different from that of the river water
  - in fact, water quality analyses indicate the river water is "better" (Ref. No. 7)
  - although water levels fluctuate with river levels, there is no evidence that the wells receive water by direct filtration from the river
- McLean Street Well
  - developed in 1971
  - the rated capacity of the well is 7600 Lpm (2000 US gpm)
  - the pump station operating capacity is reportedly in the order of 5700 to 6100 Lpm (1500 to 1600 US gpm)

- Waneta Well
  - the capacity of the well is reportedly estimated to be a minimum of 9500 Lpm (2500 US gpm)
  - a recent monitoring program has established a correlation between the water level in the well and that in the river .

In summary, the City reported that the existing 1981 sources were being utilized to maximum capacity in summer; and that during periods of peak consumption, the system was actually "water short". For that reason, as well as problems with the existing sources, the City developed the Waneta well and has been considering the feasibility of developing a replacement system based on the Columbia River source. This would involve construction of a water treatment facility comprising coagulation, sedimentation, filtration and disinfection.

Finally, it is interesting to note that in 1980 the average daily consumption was almost 9.0 megalitres (2.0MG); while over the past five year period the "peak day demand" has varied between 24 megalitres (5.3MG) and 31 megalitres (6.8MG).

2.4 Oasis-Rivervale

The approximate locations of the sources of supply for these communities are indicated on Figure 4.

Oasis

The Oasis Waterworks District services a small subdivision located on a bench above the site of the proposed Murphy Creek Dam.

The system has 36 connections, including a 4-unit motel and an engine repair shop.

Water supply is provided from 5 artesian wells of varying depths that were installed over the period 1955 - 1979. These wells are located on the hillside above the townsite and feed a 55000 litre (12,000 gallon) concrete storage tank. A 100 mm main then conveys the water through the community.

The wells reportedly rest on bedrock that is overlain by a water bearing seam of sandy material. They are subject to sanding problems, and require cleaning approximately every two years.

The wells have inadequate capacity to provide for the water supply requirements of the community, and in summer there are water shortages.

A number of homes are on private well systems.

Rivervale

The Rivervale Water Company services 110 residences and 4 businesses that are located northwest of Trail on a bench below the existing highway.

Water supply is provided from three sources.

- Hanna Creek at the north end of the townsite, and west of the highway
- Durkin Spring, approximately 0.8km south of the townsite and between the highway and railroad track

- McNally Spring, approximately 0.8 km south and just above the highway

Hanna Creek is used only for summer peaking and fireflow protection, as the two springs are adequate to meet the winter requirements.

A 9000 litre (20,000 gallon) buried concrete tank with a wood roof is located on Hanna Creek. A 200mm main conveys water through the townsite, and links up with a small diameter plastic line (possibly 30mm in diameter) from the springs. springs.

It should be noted that the springs are located at the base of a rock slide area, and are essentially seepage outflows.

2.5 Green Gables-Cutillo

The communities serviced by the Green Gables Waterworks Utility Ltd. and the Cutillo Water Company are situated on the riverbench southeast of the City of Trail as indicated on Figure 2.

The approximate locations of water supply facilities are shown on Figure 4.

Green Gables

The source of water supply is a 64 metre deep well located north of the highway. The groundwater is pumped to a 90000 litre (20,000 gallon) woodstave storage tank.

The well was drilled in 1962 and is 300 mm in diameter with 6 metres of 250mm slotted casing.

The well was pump tested at 680 Lpm (180 US gpm), and was rated at 590 Lpm (155 US gpm) in 1964. Until this year, the well pump was a submersible type with a 15 hp motor and a capacity of 570 Lpm (150 US gpm).

The pump was replaced with one having a 20 hp motor and a capacity of 760 Lpm (200 US gpm). This has apparently resulted in over-pumping of the well, and the Utility is now making modifications to the system in order to operate the pump on the basis of well probes for low level shutdown.

The system has 80 service connections, and reportedly has adequate capacity to provide for normal water supply requirements. The system is deficient, however, in terms of providing balancing and fireflow storage.

Cutillo

The sources of water supply are two 23 m deep groundwater wells located approximately 3 metres apart on the north bank of the Columbia River.

The wells have 175 mm casings, and the submersible well pumps have 5 hp motors.

The pumps are controlled by a 1360 litre (300 gallon) pressure tank and operate at pressures between 275 Kpa (40psi) and 415 Kpa (60psi).

The system reportedly has about 15 connections.

The system has neither fireflow nor balancing storage, and is generally considered inadequate in terms of municipal waterworks standards.

2.6 Montrose-Beaver Falls-Fruitvale

The communities of Montrose, Beaver Falls and Fruitvale are situated in the Beaver Creek Valley, which is tributary to the Columbia River Valley as indicated on Figure 2.

The approximate locations of the primary waterworks facilities are shown on Figure 5.

The Village of Montrose operates its own system, whereas the Village of Fruitvale is serviced by both the Fruitvale and Beaver Falls Waterworks Districts.

The Fruitvale Waterworks District serves most of the Village as well as the outlying and surrounding residential area, while the Beaver Falls Waterworks District services the western part of the Village plus Beaver Falls.

Montrose

Water supply is obtained from a groundwater well located near the confluence of the Columbia River and Beaver Creek.

First, the water is pumped to the TWL of the Lower Zone Reservoir; and then it is booster pumped to the Upper Zone Reservoir. A by-pass valve in the booster pump station permits flow from the Upper to Lower Pressure Zone in the event of emergency conditions.

The details of the well and pump station are as follows:

- the well is 38 metres deep.
- the well consists of a 450 mm casing with the last 10 metres slotted.

- drill logs indicate that the aquifer is between 30 and 37 metres

- the pump is a vertical turbine type with a 250 hp motor

- the reported operating capacity of the pump is 2900 Lpm (640 Igpm)

- the pump has been in service for more than 18 years, and has operated for up to 18 hours per day during periods of peak demand

The waterworks system mainly comprises 150 mm and 200 mm piping, and is generally in accordance with normally accepted municipal standards.

Beaver Falls

Water supply is obtained from a groundwater well located beside Beaver Creek. The system includes a tie-in to the Montrose system in order to provide a source of emergency supply. The valves for this tie-in must be manually operated.

Water is pumped to a 159,000 litre (35,000 gal.) steel tank via a 150 mm main.

The details of the well and pump station are as follows:

- the well was developed in 1973 and is 21 metres deep

- the well consists of a 250 mm casing, with the last 7½ metres being a 200 mm diameter stainless steel screen

- drill logs indicate that the aquifer is between 11 and 21 metres

- the aquifer is reportedly recharged from the creek.

- during development, the well was pump tested at 1155 Lpm (254 Igpm)

- the existing pumping unit has a 25 hp motor and is rated at approximately 1050 Lpm (230 Igpm)

The system has 200 service connections, and is reportedly operating at or near capacity during periods of peak demand.

The backbone of the system is the 150 mm main between the pump station and the reservoir. The system also includes some 100 mm and 50 mm piping.

The system is deficient in terms of balancing and fireflow storage.

Fruitvale

Water supply is obtained from a combination of three surface and groundwater sources as follows:

- Kelly Creek to the south

- Fruitvale Creek to the north

- Maple Avenue Groundwater Well adjacent to Beaver Creek

These sources feed a steel tank that has a TWL at El.716.46 m.

The details of the Kelly Creek source are as follows:

- the intake works are located at approximately El.768 m.

- these works include a 3m high by 30m long concrete dam
- the storage capacity of the impoundment behind the dam is approximately 0.82 megalitres (180,000 gallons)
- the dam is reportedly in need of repair
- a 300 mm supply main conveys water to the townsite
- the reliable baseflow is in the order of 0.03 cms
- this is reportedly insufficient to meet the water requirements of the community during periods of peak demand

Similarly, the details of the Fruitvale Creek source are as follows:

- the intake works are located at approximately El. 793 m
- these works include a 1½ m high by 6 m long concrete dam
- a 200 mm supply main conveys water to the reservoir
- the creek reportedly dries up by August, and therefore can only be used as a source of supply for a limited period of the year

The recently developed well is presently supplying a reported 910 Lpm (200 Igpm) to the system.

The system has approximately 800 service connections.

2.7 McGauley-Columbia Gardens-Waneta

Three relatively minor water systems that were considered in the course of this study are as follows:

- McGauley Readi-Mix Concrete Company Ltd.
- Columbia Gardens Industrial Park
- Waneta Customs House

McGauley

McGauley has a 0.90 megalitre per day (200,000 gpd) water licence on the Columbia River for the purpose of washing gravel only.
McGauley has a 50 hp motor coupled to a centrifugal pump and suction hose that is installed on a floating barge. This pump is operated 6 hours per day for 6 months of the year.

The pump is overhauled each year.

Water for domestic and batching purposes is obtained from Ryan Creek.

Columbia Gardens

A groundwater well was recently developed for supply to the new industrial park located on a bench above the river.

A new 100 Lpm (30 USgpm) well provides water supply to the municipal airport.

Waneta

At the Waneta border crossing, a groundwater well provides water supply to both Canadian and U.S. Customs.

This well supplies 3 toilets, 4 basins and 2 outdoor taps.

2.8 Private Wells

The Groundwater Division of the Ministry of Environment has provided a set of three water well location maps showing the location of wells in the Study Area for which the Ministry has records on file; also copies of a number of the well records.

Private wells are mainly located in Oasis, with several others in the Columbia Gardens area.

2.9 Summary

Two summary tables have been prepared based on the information presented in the foregoing sections. These are as follows:

- Table 3 is a summary of existing sources of supply and reported capacities, including system storage
- Table 4 is a summary of system capacities as compared to water supply requirements during the day of peak demand

With reference to Table 3, the following points should be noted:

- no data are available with respect to the capacities of the Oasis, Rivervale and Cutillo systems
- the rating of the Cominco system is based on the pumping capacity of the Stoney Creek Pump Station.

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- the rating of the Cominco system is based on the pumping capacity of the Stoney Creek Pump Station.

- the capacity ratings for Tadanac and Warfield are assumed to be equivalent to the water treatment plant capacities
- for Trail's Violin Lake-Cambridge Creek source, the rating of 17 megalitres per day (3.8 MGD) is based on the reported hydraulic capacity of the existing 300 mm gravity supply main
- including the new Waneta well, the combined capacity for Trail's four groundwater well pump stations is in the order of 27 megalitres per day (6MGD) based on the current effective well yields

With respect to Table 4, the following points should be noted:

- for communities that have no records on water usage, an allowance of 2700 litres per capita per day (600 gpcd) has been used as a basis for assessing the magnitude of the peak day water demand
- for Tadanac, the capacity of the water treatment plant is significantly greater than the domestic requirements
- for Warfield, the water demand is greater than the treatment plant capacity; but as noted in Section 2.2, Cominco supplements Warfield's supply by up to 25 per cent with untreated water during periods of peak usage
- the peak day water demand for the City of Trail is approaching the combined capacity of the existing surface and groundwater sources
- communities that are "water short" are Beaver Falls, Fruitvale, and Oasis

Finally, it should be noted that the figures on peak day demand and system capacity for Montrose-Beaver Falls-Fruitvale-Green Gables-Cutillo were obtained from Reference No. 2 and have not been independently verified.

The peak day demand for the City of Trail is based on the City's records for the period 1976-1980.

TABLE 3 - SUMMARY OF EXISTING COMMUNITY WATER SUPPLY SOURCES

COMMUNITY	SOURCES			SYSTEM STORAGE		COMMENTS/PROBLEMS
	DESCRIPTION	CAPACITY RATING* (MLPD)	CAPACITY RATING* (MGPD)	(1000 L)	(1000 G)	
Oasis	5 artesian wells	-	-	55	12	- water shortages in summer - some homes are on private wells.
Rivervale	2 springs and 1 creek	-	-	90	20	- springs provide base demand - creek provides fire protection and summer peaking.
Cominco Ltd.	Columbia River	428.00	94.00	20,500	4,500	- supplies Tadanac & Warfield
Tadanac	Cominco Ltd.	2.70	0.60	565	124	- supplied from water treatment plant operated by Cominco.
Warfield	Cominco Ltd.	4.60	1.00	4,550	1,000	- supplied from water treatment plant operated by Cominco.
Trail	Violin Lake-Cambridge Creek	17.20	3.80	14,000	**3,079	- declining quality.
	Sunningdale Well No. 1	3.00	0.66			- declining capacity & quality.
	Sunningdale Well No. 2	1.70	0.37			- declining capacity & quality.
	McLean Street Well	8.60	1.90			- no problems reported.
	Waneta Well	13.70	3.00			- developed in 1981
Cutillo	2 groundwater wells	-	-	-	None	- system generally inadequate.
Green Gables	1 groundwater well	0.90	0.22	90	20	- adequate source capacity, but insufficient storage.
Montrose	1 groundwater well	4.20	0.92	1,365	300	- system generally in accordance with municipal standards.
Beaver Falls	1 groundwater well	1.50	0.33	160	35	- system storage is insufficient to provide a minimum fireflow reserve.
Fruitvale	Kelly Creek	2.70	0.60	1,960	430	- this baseflow is insufficient during peak demand periods.
	Fruitvale Creek	-	-	-	-	- creek dries up in summer; not reliable.
	1 groundwater well	1.30	0.29	-	-	- well developed only recently.

* Rating is in terms of both "million gallons per day" (i.e. "MGPD") and "million litres per day"(i.e."MLPD")

** In addition, the lake sources provide a storage reserve estimated to be in the order of 290 million gallons(1320 megalitres)

TABLE 4 -SUMMARY OF EXISTING COMMUNITY WATER SUPPLY SYSTEM CAPACITIES

COMMUNITY	PRESENT POPULATION *		SYSTEM STORAGE (gallons)	PEAK DAY DEMAND**		SYSTEM CAPACITY**		COMMENTS
	DWELLING UNITS	PEOPLE		(MLPD)	(MGPD)	(MLPD)	(MGPD)	
Oasis	36	160	12,000	0.27	0.06	-	-	- no data available - water restrictions necessary in summer; otherwise there are shortages
Rivervale	110	260	20,000	0.80	0.18	-	-	- no data available, but all 3 sources required to supply peak demand in summer.
Tadanac	74	200	124,000	0.57	0.13	2.70	0.60	- an allowance must also be made for water used in the bottling plant at Cominco.
Warfield	730	2,050	1,000,000	5.60	1.23	4.60	1.00	- the deficiency in system capacity correlates with the fact that Cominco supplements Warfield's supply by up to 25% with untreated water.
Trail	3,810	9,600	3,079,000	31.00	6.8	44.20	9.73	- until the new Waneta well was developed, demand was approximately equal to capacity of the original system (6.73MGPD)
Cutillo	15	50	None	0.14	0.03	-	-	- no data on existing well is available.
Green Gables	80	250	20,000	0.64	0.14	0.90	0.20	
Montrose	370	1,229	300,000	2.90	0.64	4.20	0.92	- system is marginally adequate.
Beaver Falls	200	640	35,000	1.80	0.40	1.50	0.33	- system is deficient.
Fruitvale	800	2,560+	430,000	3.20	1.70	4.00	0.89	- in a drought year, there is insufficient flow in Kelly Creek to provide for anything other than normal requirements. - in a normal year the system is marginally adequate.

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* Population figures are based primarily on data provided by DPA Consulting Ltd. (Ref. No. 6)
** Data given in terms of both "million gallons per day" (i.e. "MGPD") and "million litres per day" (i.e. "MLPD")
+ Population within the waterworks district.

3. WATER USER CONCERNS

3.1 Introduction

The potential impact of the Murphy Creek Project on downstream water users was referred to in Section 1 in terms of two factors:

- turbidity in the Columbia River
- increased water supply requirements in existing communities

The purpose of this section is to report in more detail specific concerns and possible problems for water users located downstream of the project site. This information will provide a basis for assessing the extent to which the project may have an impact on downstream water supply systems.

The information presented herein fulfills the requirements of Item 3 of the "inventory phase" of the Terms of Reference (i.e. "document public and commercial concerns with respect to water use").

The focus in this section is on turbidity. The significance of increased water demand as a result of population growth generated by the Project is discussed in a subsequent section.

3.2 Cominco-Tadanac-Warfield

Cominco

Three areas of concern have been identified with respect to operation of the Cominco water supply system. These concerns relate to:

- flow rates and water levels in the Columbia River
- turbidity and suspended sediment levels in the river
- debris in the river

The general concern on the part of Cominco is that major changes in river conditions (in terms of the above noted factors) could possibly result in either a partial or complete shutdown of Cominco's industrial complex. Cominco have also suggested that even if there is no shutdown of operations, Cominco could still incur significant costs in taking preventative action.

Reasons for concern with respect to water levels in the Columbia River are as follows:

- as noted in Section 2.2, the minimum river level required for "normal" operation of the pumps in the Stoney Creek Pump Station corresponds to a reading of 3 ft. on the staff gauge that is affixed to the outside wall of the pump station
- as the level drops from 3 ft. to 0 ft., some plant cutbacks may be necessary depending upon total water demand and pump efficiency
- as the "O" level is approached, the pumps lose efficiency, resulting in increased power costs if low water conditions persist for an extended period
- below the "O" level, Cominco would probably have to curtail operations due to vortexing at the intakes

The minimum steady flow required for satisfactory pump station operation (as noted in Section 2.2) is 425 cms which corresponds to about 0.5 ft. on the staff gauge.

This flow rate would in fact be the minimum maintained downstream of the Murphy Creek Project under normal operating conditions. (Reference No. 1)

The two other factors introduced previously (i.e. turbidity levels and debris) are of particular concern to Cominco during the construction period.

By debris, Cominco are referring only to material that would pass through the 20 mm mesh intake screens, or plastic sheeting floating in the river that could plug the intakes. The specific concerns are:

- the necessity to inspect and clean the Stoney Creek Pump Station intake screens on a more frequent basis than under normal conditions
- the possibility (even if remote) that the sewer outfall could be damaged by material moving along the river bed

Turbidity is the more significant of the two factors because of the potential for an impact on both the water supply system and the industrial plant operation.

Turbidity, as noted in Section 1.4, is a term that refers to sediment matter that is held in suspension by the water. The term"turbid"is applied to waters containing suspended matter that interferes with the passage of light through the water,or in which visual depth is restricted. The turbidity may be caused by a wide variety of suspended materials, which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence.

Cominco make a distinction between sand and silt when discussing the effects of turbidity.

The concern with respect to coarse sand relates to two facilities:

- the Stoney Creek Pump Station
- the Flumehouse Reservoir

Based on their previous experience during construction of the Keenleyside Dam at Castlegar, Cominco have suggested that frequent and extensive overhauls of the 11 pumps in the Stoney Creek Pump Station may be required during construction of the Murphy Creek Dam. The probable need for such overhauls is based on the assumption that high concentrations of coarse sand will result in excessive wear on the pumps - particularly the impeller wear rings, seal rings, centre bushings on two-stage pumps, and on shaft sleeves and packings.

The Flumehouse Reservoirs serve a dual function: water storage; and as settling basins. It is therefore assumed that most of the coarse sand would settle out in the reservoirs. This, in turn, would necessitate cleaning out the reservoir on a more frequent basis than under normal conditions.

The detention time in the reservoirs is relatively short. It is therefore assumed that water distributed from the Flumehouse complex to the domestic water treatment plants and to the industrial process plants could be laden with fine and colloidal silts.

Cominco have identified three possible effects resulting from silt-laden water:

- plugging of screens and filters on distribution lines throughout the process plants

- reduced boiler efficiency in the NGA plant
- overloading of the two filtration plants that provide domestic water supply (for Tadanac and Warfield)

On the matter of the boilers, Cominco report that "the NGA plant boilers and the No. 1 and No. 2 electric boilers do not presently have filters". Apparently the significance of this is that the resulting buildup of deposits on heating surfaces would affect boiler efficiency, thereby necessitating more frequent boiler cleanouts.

In summary, Cominco's over-riding concern with respect to turbidity relates mainly to possible increased maintenance costs (e.g. changing filters). Underlying this concern, however, is the worry that severe levels of suspended sediment resulting from construction activity could cause either a partial or complete shutdown of production.

Tadanac and Warfield

The primary concern for the domestic water supply to the residential communities of Tadanac and Warfield relates to the operational capabilities of the two existing water filtration plants; in other words, the treatment effectiveness under conditions of extreme turbidity.

The secondary concern relates to the fact that, during periods of peak demand in summer, the water supply requirements for the Village of Warfield exceed the capacity of the water treatment plant. Therefore, Cominco provides a supplementary supply of untreated water directly from the Warfield Headtanks. This supplementary requirement is typically in the order of 25 per cent of the plant capacity.

The fact that the Village is using "untreated" water could be of critical importance if the quality of that water declines as a result of increased turbidity caused by construction activity related to the Murphy Creek Project. In this regard, it should be noted that the public health significance of turbidity is that high levels of turbidity interfere with the disinfection process by protecting micro-organisms from chlorine. The suspended materials causing the turbidity may also act as a food source for micro-organisms so that they can survive and multiply in the water distribution system.

3.3 Trail

The Terms of Reference for this study provide for an assessment of the potential impact of the Murphy Creek Project on both existing and possible future downstream waterworks systems that utilize the Columbia River as a source of supply. Although the City of Trail does not currently take water directly from the river, it is actively considering the feasibility of utilizing river water in the future. The planning is not sufficiently advanced, however, to project an in-service date.

The City formerly had a pump station intake on the Columbia River. This was constructed in Sunningdale in 1948 to supply East Trail, and was removed from active service in 1964 when B. C. Hydro provided the two replacement wells described in Section 2.3.

The concept of providing Trail's total water supply requirements from the Columbia source was first proposed in Reference No.7. That report envisioned a "full scale water treatment process" involving primary sedimentation, straining, coagulation, fine sedimentation, filtration and chlorination.

The reasons for renewed interest in this proposal are as follows:

- the two wells in Sunningdale are declining in both quantity and quality
- the Violin Lake-Cambridge Creek system is not considered a reliable long-term source of supply
- if the Violin Lake-Cambridge Creek storage reserve was emptied in a drought year, it would reportedly take three years for the reservoir to re-fill under normal conditions
- the limited flushing action through Violin Lake has reportedly resulted in a deterioration in water quality because of algae growth in late summer
- the existing sources of surface and groundwater supply are marginally adequate to provide for present day peak demands
- the addition of a new well in Waneta is offset to some degree by the declining output of the existing sources

In summary, then, the City has commissioned an engineering pre-feasibility study to provide a basis for decision making with respect to a replacement Columbia River Water Supply System. For this reason, the City is concerned about the impact that construction of the Murphy Creek Project might have on water quality. The City accepts that the river water must be treated with or without the Murphy Creek Project. The concern relates mainly to whether or not the Project could have a short-term affect on water treatment requirements.

3.4 Oasis-Rivervale

Oasis

The concern originally expressed by the residents of Oasis with respect to the 5 artesian wells comprising the supply system related to their possible vulnerability to rock blasting activity.

This concern is addressed in a separate groundwater study (Ref. No. 8), wherein it is concluded that "it seems most unlikely that construction of a dam at Murphy Creek will interfere in any way with water supply from the wells now supplying the residents of Oasis."

Rivervale

The concern originally expressed by the residents of Riverdale related to the potential impact of possible highway relocation work on Durkin and McNally Springs.

However, no relocation work is planned in the vicinity of these springs (Ref. No. 1).

3.5 Montrose

The Village of Montrose obtains water supply from a groundwater well as described in Section 3.6. According to a groundwater hydrology study incorporated in Reference No. 2, the main aquifer feeding this well is probably part of the ice contact sediments in the Columbia Valley. The report notes that these "ice contact sediments tend to be rather fine grained, but they do contain some coarse, clean gravel, which is highly productive".

The specific concern that has been expressed by representatives of the Village is that a deterioration in the quality of the Columbia River could somehow impair the productive capacity and/or quality of the well.

It has also been reported that there is a freeze on land development on the basis that the existing water supply system has inadequate capacity to provide for a significant increase in population. Based on information presented in the November 1980 Report, it appears that the system is marginally adequate to provide for present day demands. The reasons for this conclusion are as follows:

- the estimated peak day demand is in the order of 2000 Lpm (440 gpm)
- this is equivalent to the pump operating for approximately 16½ hours per day
- it is reported that the pump has operated for up to 18 hours in a day in recent years
- the design of the system was apparently based on operating the pump for a maximum of 16 hours per day

Reference No. 2 included a review of various alternative sources of supply, including the Columbia River, and recommended developing a second groundwater well further upstream on Beaver Creek near the eastern boundary of the Village.

The Columbia River was rejected as a possible source on the basis of cost considerations.

3.6 Summary

The accompanying Table 5 provides a summary of specific concerns identified in foregoing sections with respect to possible impacts on a number of downstream water supply systems. These concerns relate to water quality. The capability of existing systems to provide for possible future population growth is dealt with in a separate section.

Table 5 also incorporates a preliminary assessment of the significance of these concerns. Key conclusions are as follows:

- there is no impact on the existing sources of supply for Trail, Montrose, or Oasis-Rivervale

- suspended sediment caused by construction activity could potentially impact the Cominco system

On the matter of the Cominco system, then, the issue to be resolved is whether the proposed method of dam construction could increase turbidity and suspended sediment levels in the Columbia River to the critical point where curtailment of construction activity would be necessary in order to avoid impact on Cominco's Trail operation. (This is dealt with in Section 4.)

TABLE 5 - SUMMARY OF CONCERNS AND PRELIMINARY ASSESSMENT OF POSSIBLE IMPACT ON EXISTING WATER SUPPLY SYSTEMS

COMMUNITY*	EXISTING SOURCES(S)	WATER USER CONCERNS	CONCLUSIONS
Oasis	Groundwater	- impact of nearby rock blasting activity	- subject of a separate groundwater study - no impact
Rivervale	Surface water		- no impact
Cominco Ltd.	Columbia River	- minimum river flow of 425 cms be maintained - extremely turbid river conditions could result in significant maintenance costs, and possible partial or complete shutdown of production	- under normal operating condition, Murphy Project would maintain 425 cms - the matter of turbidity and suspended sediment levels is dealt with in Section 4 in order to assess the critical significance of various levels
Tadanac	Columbia River	- treatment effectiveness of filtration plant under conditions of extreme turbidity	- to be assessed in conjunction with detailed investigation of significance of turbidity
Warfield	Columbia River	- treatment effectiveness of filtration plant under conditions of extreme turbidity - public health implications of using "untreated" turbid water during periods of peak water demand	- to be assessed in conjunction with detailed investigation of significance of turbidity
Trail	Groundwater & surface water	- water treatment requirements for a New Columbia River Water Supply System that might replace existing system	- if the Columbia River is developed as a replacement source, existing sources presumably would still be available on a standby or emergency basis - therefore, Murphy Creek Project does not have any impact on either existing or future systems

TABLE 5 -SUMMARY OF CONCERNS AND PRELIMINARY ASSESSMENT OF POSSIBLE IMPACT ON EXISTING WATER SUPPLY SYSTEMS

COMMUNITY*	EXISTING SOURCES(S)	IDENTIFICATION OF POTENTIAL PROBLEMS	CONCLUSIONS
Montrose	Groundwater	- concern that capacity and/or quality of existing well could be impacted - future possibility of using Columbia River source for water supply	- short-term turbidity in surface water not a factor with respect to ground water - a recently completed water study for Montrose ruled out the future use of the Columbia River on the basis of cost, and recommended a 2nd well in Beaver Creek - therefore, Murphy Creek Project does not have an impact on either existing or future systems

*Note that only communities which may be possibly/potentially impacted are listed herein. For other communities (e.g. Fruitvale) there is no possibility of impact.

PART B - PROJECT IMPACTS

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4. WATER QUALITY DURING CONSTRUCTION

4.1 General

Key parameters for assessment of the possible impact of construction on water quality are suspended solids and turbidity. In this regard, it is important to note that:

- the Cominco industrial complex at Trail is located immediately downstream of the Murphy Creek damsite, and depends solely on the Columbia River for water supply
- construction activity in or adjacent to the river could result in increased levels of turbidity and suspended sediment in the river
- Cominco is concerned that extreme levels of turbidity and suspended sediment could affect plant operations

The issue to be resolved, as noted in Section 3.6, is whether the proposed method of dam construction could increase suspended sediment and turbidity levels in the Columbia River to the critical point where curtailment of construction activity would be necessary in order to avoid impact on Cominco's operations.

Analysis of this issue involves consideration of three factors:

- baseline (i.e. existing) levels of turbidity and suspended sediment in the river under natural conditions
- the threshold (i.e. maximum) level of turbidity or suspended sediment that Cominco can tolerate without any noticeable impact on either the industrial operations or the domestic water treatment plants

- the extent to which the proposed method of diversion channel excavation and dam construction for the Murphy Creek Project could generate increased turbidity and suspended sediment

The purpose of this section is to provide an overview of the foregoing matters, and to outline a course-of-action for mitigating the possible adverse impacts of construction activities.

4.2 Previous Experience

Present concerns expressed with respect to turbidity and suspended sediment in the Columbia River relate to previous experience during construction of the Hugh Keenleyside Dam near Castlegar in 1965.

In anticipation of water quality problems at that time, B. C. Hydro provided the following facilities for those waterworks systems based on Columbia River supply:

- water treatment plants for Tadanac and Warfield to ensure a continuous supply of filtered water acceptable for domestic purposes

- two groundwater wells in Sunningdale to replace Trail's river intake

- groundwater well to replace the former Village of Kinnaird's river intake

- pump station intake on the Arrow Lakes above Keenleyside Dam to replace CanCel's (BC Timber Ltd.) river intake system

During construction of the dam, suction dredging and earthfill operations discharging directly into the river reportedly resulted in noticeable turbid conditions for short durations. The West Kootenay Health Unit's concern with public health implications resulted in a monitoring program beginning in 1965. Turbidity was measured at the Tadanac Water Treatment Plant on a daily basis, and the results of this data gathering program are reproduced herein as Figure 6. (Ref. No. 7)

Although Figure 6 starts with December 1965, data for the period July - October 1965 are also available and are listed in Table 6. The key points to note are:

- the maximum permissible limit of turbidity for community water supply in British Columbia is 5 JTU (i.e. Jackson turbidity units)
- through July and August 1965, turbidity levels were below the limit of 5 JTU
- by September 1965, the levels were consistently exceeding the limit of 5, and were typically in the order of 10 JTU
- in December 1965, extreme levels of up to 50 JTU were being reached for brief durations

Cominco report that construction of Keenleyside had an impact on their operation in terms of both pump wear and plugging of intake screens at the Stoney Creek Pump Station. This was attributed to the increased suspended sediment load in the river. Cominco have not been able to quantify the magnitude of this impact.

4.3 Methods of Dam Construction

The procedure for constructing the Murphy Creek Dam would differ radically from that employed in constructing the Hugh Keenleyside Dam. The latter was built "in the wet", by discharging suction

TABLE 6 - SUMMARY OF TURBIDITY DATA AT TADANAC DURING THE PERIOD JULY - OCTOBER 1965*

	TURBIDITY READING IN 'JACKSON TURBIDITY UNITS'			
DATE	JULY	AUGUST	SEPTEMBER	OCTOBER
1	2.1	2.3	7.5	12.7
2	2.0	2.3	15	12.5
3		3.1	3.6	5.5
4			18	1.3
5		2.3	20	12.5
6		2.5	18	16.0
7	6.3*		2.3	6.3
8			10	19.0
9	6.0	1.6	22	10.0
10		2.6	18	2.7
11		2.6		1.8
12	6.0	2.8		1.9
13	4.5	2.6	8	
14	4.5		9.5	
15	4.5		9.5	
16		4	8.5	
17			6.5	0.1
18		7	5.5	1.5
19		12	19	0.1
20	2	5.5	6	0.1
21	2		10	3.5
22	2		10	
23	2	10.5	7.5	
24	2	2.9	9.5	
25	2	2.1	7.5	
26	2	3.2	5	
27	2		1.9	
28	3.2		4	
29	2.3			
30	2.3	3.9		
31	2.3			

* Monitored at Tadanac WTP by West Kootenay Health Unit

dredged silt material and end dumping earthfill directly into the river.

The Keenleyside concrete structure cofferdam required the removal of large quantities of silt in order to prepare its foundation. The silt was removed from the bottom of the river by two large suction dredges which redeposited the excavated material back into the river downstream of the site. Most of this excavation work was undertaken in the late fall and early winter of 1965. Thus, there is a correlation with the high turbidity levels shown on Figure 6 for that period.

Murphy Creek Dam would be mainly built "in the dry", behind a cofferdam. No discharge of dredged material is anticipated.

It is important to note that the "in the wet" method of construction using material fine enough to be carried off in suspension results in turbid river conditions. River velocities and suspended particle sizes would vary the downstream impact.

The proposed procedure for river diversion and dam construction is illustrated by Figure 7, and described as follows in Reference No. 1:

- Initial construction work would involve rock excavation for the approach and tailrace channels on the right (west) bank of the river. During this phase of the work no diversion is required.

- First stage diversion would direct the Columbia River to the left (east) bank of the existing river channel by a cellular cofferdam.

- It would be necessary to widen the river channel by excavating and protecting the left bank to maintain acceptable water levels during diversion.

- The construction of the cellular cofferdam and widening of the river channel would be undertaken "in the wet".

- Powerhouse and channel excavations would be protected by upstream and downstream rock plugs.

- Second stage diversion would comprise two rockfill dykes in the existing river channel diverting flow through the completed spillway.

- Upstream and downstream channel rock plugs and part of the cellular cofferdam would be removed in the wet prior to construction of the dykes.

- An earth/rockfill cofferdam would be constructed around the uncompleted powerhouse or rock plugs left in place prior to diversion.

- Removal of the cellular cofferdam would be completed after diversion.

- The powerhouse cofferdam of rock plugs would be removed partially in the wet prior to reservoir filling.

It is also understood that:

- the major portion of the east bank excavation would be above the river level, and would be done in the dry

- the portion of the work below the river level would then presumably be done in the wet using a dragline.

Although the two-stage approach would minimize disturbance to the riverbed, there is still potential for sediment discharge as a result of diversion channel excavation and cofferdam construction.

Possible sources of sediment include:

- excavated material lost in the course of excavating the east bank and draglining below the river level
- scouring of the de-stabilized section of river bed
- 'rock flour' swept away by the river current during the dumping operation for the rockfill dykes
- material lost in the course of removing the cofferdams

Suspended sediment concentrations generated by the Murphy Creek Project construction activities would be a function of two factors:

- rate(s) of flow in the river during the critical period(s)
- rate(s) of sediment discharges from the above noted sources

A third factor related to suspended sediment levels is the transportability of the material that is likely to be swept down river - in other words, the type and size range of both native and imported construction materials determine whether the materials move as bed load or are carried in suspension.

The proposed "in the dry" method of construction for Murphy Creek is relatively controlled in comparison with the construction method employed at Keenleyside. Although four possible sources of sediment discharge have been identified, the quantity of material likely to be generated from any one source is probably not of a great magnitude. The most significant activity in terms of having a noticeable impact on the appearance of the river would likely be the dragline operation, as it would involve working in the river bed.

In summary, then, the proposed "in the dry" method of construction would minimize significantly any impact on river quality.

The foregoing discussion has been in terms of the on-site sources of sediment. Equally significant, however, are the off-site sources - in particular, the borrow pit operations.

The development of borrow pits will involve extensive clearing of tributary watershed areas. These activities could potentially yield relatively large quantities of sediment unless standard engineering protective measures are implemented as part of a sediment containment plan.

4.4 Baseline Data

Available data on Columbia River turbidity is essentially limited to information from the West Kootenay Health Unit (WKHU) for the period 1965-1968. This daily monitoring was discontinued in mid-1968. In recent years, measurements have been on a random basis in conjunction with periodic water quality sampling and testing of domestic supply sources.

Turbidity was monitored at the Tadanac Water Treatment Plant, which includes a turbidimeter complete with a 12mm sampling line from the Columbia River source. Cominco have advised, however, that there has been no program of monitoring; nor has any record been kept of the quality of the inflow to the plant.

With respect to Figure 6, the key points to note are as follows:

- for the period 1966-1968, turbidity was generally less than 5 JTU (i.e. the Provincial standard)
- on the occasions when turbidity exceeded 5 JTU, the duration was generally in the order of two to three days
- turbidity rarely exceeded about 7 to 8 JTU

- the peak values of turbidity were recorded during the November-January period

Based on a review of the original data sheets provided by the WKHU, a value of about 2 JTU is representative of turbidity throughout most of the year.

Another indicator of water quality is the suspended sediment concentration in the river. Measurements have been taken at Birchbank since August 1965. Reference No. 4 provided the following summary comment with respect to these measurements:

> *The pattern of monthly suspended sediment loads was altered in 1968 with the construction of Keenleyside Dam and the periods of record before and after 1968 are too short to warrant any quantitative comparison. However, a perusal of the suspended sediment load record indicates that the May-to-September suspended sediment loads have decreased since the construction of Keenleyside Dam and since regulation of flows according to the Columbia Treaty.*

The suspended sediment concentration and load data are summarized in Table 2-7, as extracted from Reference No. 4. This table provides a perspective with respect to the magnitude of sediment transport by the Columbia.

Key points to note are as follows:

- peak months for sediment transport are May, June and July

- average daily load is generally in the order of 1500 tonnes during during this period

- maximum daily suspended sediment concentrations are generally less than 50 mg/l

TABLE 2-7

COLUMBIA RIVER AT BIRCHBANK - STATION NO. 08NE049

MONTHLY MEAN SUSPENDED SEDIMENT LOAD IN TONNES PER DAY

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1965	---	---	---	---	---	---	---	8 550	4 520	1 830	1 070	1 050
1966	549	762	763	1 330	4 200	8 900	3 650	3 360	957	824	946	376
1967	496	695	511	667	3 710	16 700	7 620	3 640	1 310	1 370	930	577
1968	472	505	426	710	4 560	15 300	7 310	1 720	811	520	500	699
1969	485	445	536	1 000	4 840	6 590	3 430	1 370	322	334	626	663
1970	602	387	325	290	1 860	1 830	646	969	550	573	906	460
1971	753	686	529	417	3 536	3 630	1 560	1 350	532	371	687	575
1972	716	330	534	577	3 120	6 190	1 970	1 170	607	356	756	862
1973	623	571	535	763	1 300	1 830	1 350	863	557	463	357	510
1974	574	516	607	629	1 736	6 390	4 990	676	363	329	602	770
1975	726	752	524	620	1 110	1 550	707	560	291	304	410	701
1976	615	776	617	802	1 770	1 630	3 330	1 670	630	630	335	391
1977	293	395	310	505	1 600	1 880	724	309	100	339	626	667
1978	783	831	861	770	1 610	1 670	1 310	693	1 050	535	935	1 100
MEAN	612	573	560	748	2 680	5 410	2 090	1 620	903	591	658	657

COLUMBIA RIVER AT BIRCHBANK - STATION NO. 08NE049

ANNUAL EXTREMES OF SUSPENDED SEDIMENT CONCENTRATION AND LOAD
AND
ANNUAL TOTAL AND ANNUAL MEAN SUSPENDED SEDIMENT LOAD

YEAR	SUSPENDED CONCENTRATION (mg/L)		SUSPENDED SEDIMENT LOAD (t/d)		ANNUAL TOTAL LOAD (t)	ANNUAL MEAN LOAD (t/d)	YEAR
	MAXIMUM DAILY	MINIMUM DAILY	MAXIMUM DAILY	MINIMUM DAILY			
1965	---	---	---	---	---	---	1965
1966	75 ON JAN 08	3 ON JUL 20	15 300 ON JUN 09	234 ON DEC 31	850 307	2 330	1966
1967	38 ON JUN 09	1 ON NOV 24	23 100 ON JUN 22	61.6 ON NOV 24	1 137 240.6	3 090	1967
1968	189 ON JUN 03 *	3 ON FEB 21	53 600 ON JUN 03 *	161 ON FEB 21	990 069	2 710	1968
1969	43 ON JUN 24	2 ON SEP 05	33 300 ON JUN 24	195 ON SEP 19	626 154	1 720	1969
1970	19 ON MAY 03	1 ON NOV 08	6 810 ON JUN 08	133 ON NOV 08	278 401	763	1970
1971	35 ON MAY 13	1 ON JUL 28	13 500 ON MAY 13	118 ON DEC 25	446 089	1 220	1971
1972	41 ON MAY 31	1 ON JUL 29	28 800 ON MAY 31	105 ON SEP 13	509 898	1 390	1972
1973	16 ON JUN 06	1 ON JAN 08	3 970 ON JUN 26	74.8 ON DEC 22	278 209.7	762	1973
1974	51 ON JUN 17	1 ON AUG 14	15 700 ON JUN 17	123 ON OCT 05	428 360	1 170	1974
1975	23 ON MAY 15	2 ON FEB 25	3 440 ON JUL 21	135 ON OCT 23	253 399	694	1975
1976	20 ON MAY 11	0 ON DEC 21 *	5 630 ON MAY 11	0 ON DEC 21 *	354 629	969	1976
1977	21 ON MAY 24	0 ON JAN 11	5 100 ON MAY 24	0 ON JAN 11	208 980.1	573	1977
1978	16 ON JUN 06	0 ON OCT 08	3 220 ON SEP 05	0 ON OCT 08	371 173	1 020	1978
					517 000	1 420	MEAN

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

LOCATION - LAT 49 10 40 N　　DRAINAGE AREA 88 100 km²　　INTERNATIONAL GAUGING STATION
LONG 117 43 15 W　　REGULATED FLOW SINCE 1931
REMARKS - SEDIMENT SAMPLES COLLECTED AT 08NE058)

(Reproduced from B.C. Hydro Report No. H 1350, "Hydrology, River Morphology and Climate", April 1981)

- in the 1970's (i.e. post-Keenleyside era), extreme values range up to 20,000 tonnes per day

The foregoing provides a basis for comparison with data that may be developed with respect to sediment loading contributed by the construction sources (i.e. as identified in Section 4.3). It also enables an assessment of the "maximum level" under natural river conditions.

4.5 Effect on Cominco

The approach followed with respect to assessing a change in water quality on Cominco is as follows:

- develop a baseline reference on present natural levels of turbidity and suspended sediment, with the objective of quantifying the "maximum level" experienced previously

- determine whether the "maximum level" under natural conditions has ever resulted in either a partial or complete shutdown of Cominco's operations, with the objective of establishing a "threshold level" below which one could confidently state that turbidity definitely has no impact on Cominco

- assess the probability of this "threshold level" being exceeded as a result of diversion channel excavation and cofferdam construction

In order to draw firm conclusions as to the significance of turbidity and suspended sediment on the operation and maintenance of industrial production processes, information is required on the sensitivity of these processes to changes in turbidity and suspended sediment levels. For this reason, Cominco were requested to comment on the following questions:

- over what range of turbidity levels is there no measurable effect or cost related to the operation and maintenance of the production processes?

- at what turbidity level could problems begin to occur?

- what would be the nature of these problems?

- what would be the significance of these problems in terms of the overall plant operation?

- what would be the significance of these problems in terms of an extra cost to Cominco?

- under what circumstances could highly turbid water result in either a partial or complete shutdown of operations?

In discussions with Cominco staff, the following key points emerged with respect to the operational history of the Trail complex:

- Cominco are unable to quantify the relative significance of various levels of turbidity

- Cominco are unable to document specific problem areas

- there is no record of either a partial or complete shutdown of operations as a result of turbid water conditions

- in the pre-Keenleyside era when the flow in the Columbia was unregulated, there were reportedly several occasions during the spring freshet period when every available plumber worked full-time for several days in order to keep filters functional

- during construction of Keenleyside, the impact on Cominco was apparently minimal

- since completion of Keenleyside, there has been no problem

On the basis of investigations carried out in response to our request, Cominco have confirmed that existing filters and process screens in the various plants are capable of handling the "maximum level" of turbidity that has been experienced previously. Cominco have also indicated that a major research effort would be required in order to establish the level of turbidity at which problems could begin to occur.

The key findings from previous sections are as follows:

- the maximum level of turbidity recorded by the WKHU in the Columbia River at the Tadanac WTP was 51 JTU on December 19, 1965 during construction of Keenleyside
- the maximum daily suspended sediment concentration recorded at Birchbank was 109 milligrams per litre on June 3, 1968

- the corresponding maximum suspended sediment load was 52,600 tonnes on June 3, 1968

The above figures therefore represent the "maximum" recorded river condition that has been experienced by Cominco.

Based on the information presented in Section 4.3 relative to the method of dam construction, and considering that the maximum level of suspended sediment in the river occurred durign the construction period of the Hugh Keenleyside Dam, the probability of the extreme values listed above being exceeded during construction of Murphy Creek is low.

4.6 Effect on Water Treatment Plants

The Tadanac and Warfield water treatment plants are based on the rapid sand filtration process, although the sand media in the Warfield plant has been replaced with a semi mixed-media in order to increase the plant's water supply capacity. No data are available, however, for the relative effectiveness of either plant at various levels of turbidity.

The impact on a filtration plant as a result of increasing turbidity is mainly in terms of the frequency of backwashing. "Backwashing" refers to the process of cleaning the filter media by means of a hydraulic upflow.

During the service cycle of filter operation particulate matter removed from the applied water accumulates on the surface of the grains of the filter media and in the pore spaces between grains. With continued operation of a filter the materials removed from the water and stored within the filter bed reduce the porosity of the bed. This has two effects on filter operation; it increases the head loss through the filter and increases the shearing stresses on the accumulated floc. Eventually the total hydraulic head loss may approach or equal the head necessary to provide the desired flow rate through the filter, or there may be a leakage or breakthrough of floc particles into the filter effluent. Just prior to either of these potential occurrences, the filter should be removed from service for cleaning. Following the washing process, water should be filtered to waste until the turbidity drops to an acceptable level.

The more turbid the water, the quicker the particulate matter accumulates; and the more often the filter must be backwashed. Cominco advise that under "normal" conditions the filters are backwashed about every 20 hours; whereas during the spring freshet backwashing is typically required every 6 to 8 hours.

In water treatment, the general practice is to reduce the turbidity of water to 10 JTU before application to rapid sand filters. In this regard, the Warfield and Tadanac plants both incorporate a sedimentation tank in the treatment process. In addition, the Flumehouse Reservoirs function to some extent as primary settling basins. In short, the turbidity of the raw river water is substantially reduced by the time it is applied to the filters.

It is significant to note that mixed-media filters can handle applied turbidities up to 50 JTU on a continuous basis, and will tolerate occasional turbidity peaks of 200 JTU. "Mixed-media" refers to the coarse-to-fine principle of filtration that has gradually been replacing rapid sand filtration as the standard of the water treatment industry during the past decade. The importance of this fact is that the treatment capability of the existing filter plants can be relatively easily increased by converting the plants to a fully mixed media operation. This involves replacing the existing media with an improved mixed-media. (In addition, backwash pumps and underdrain piping may need upgrading and/or replacement.)

4.7 Alternative Scenarios

With the lack of site-specific data, there is no definitive basis for assessing the impact of possible changes in water quality during construction. This necessitates consideration of a range of alternatives, with a probability assessment for each.

Three alternative scenarios are as follows:

- no impact - this assumes construction activities are relatively controlled; that sediment discharges due to these activities are insignificant in comparison with natural river sediment loading; that there is no measurable increase in turbidity and suspended sediment levels; and that there is no noticeable affect on either Cominco or the water treatment plants
- minor impact - this assumes that construction activities are relatively controlled; that sediment discharges due to construction result in a measurable increase in turbidity and suspended sediment, but the overall levels do not exceed the "maximum levels" under natural conditions

- severe impact - this assumes that construction activities are uncontrolled; that sediment discharges are significant relative to the natural river loading; that the resulting turbidity exceeds the "maximum level"; and that the Columbia River is effectively unusable for either industrial or domestic water supply purposes for significant periods during construction

A subjective assessment of occurrence probability for the foregoing alternatives is as follows:

- no impact scenario - high

- minor impact scenario - most probable

- severe impact scenario - low

For the first two scenarios, consideration need not be given to alternative plans for water supply; whereas the third scenario requires that construction activities be curtailed, or a replacement supply be provided. The latter could include either improved and/or new treatment facilities.

The critical assumption for both the "no impact" and "minor impact" scenarios is that construction activities would be controlled. In this regard, excavation work in or adjacent to the river could be scheduled and regulated on the basis of a turbidity and suspended sediment monitoring program as follows:

- if either turbidity or suspended sediment was approaching a pre-determined threshold level, then construction activities could be curtailed until the river stabilized, with subsequent minor alterations in the construction method

- if both turbidity and suspended sediment were well below a specified level, then this would "theoretically" mean that the level of construction activity could be increased

The objective would be to prevent conditions in the river reaching an "unacceptable" level.

The key to success of the monitoring program would be establishment of a baseline reference over the next few years, and prior to construction.

4.8 Summary

The significant points from the foregoing sub-sections include:

- based on a review of the available data, the maximum turbidity and suspended sediment loads occurred during the period that the Hugh Keenleyside Dam was being built
- the impact on Cominco was reportedly minimal, however, as the existing filters and process screens were able to handle the sediment loading
- the proposed "in the dry" method of construction for the Murphy Creek Project is relatively controlled and should minimize sediment discharge to the river
- it is therefore unlikely that the extreme levels of turbidity and suspended sediment experienced previously will be exceeded as a direct result of dam construction
- the capability of the existing Warfield and Tadanac water treatment plants to handle highly turbid water could be relatively easily extended by modifying the filtration process
- a turbidity monitoring program should be implemented in order to establish a baseline reference prior to construction
- the baseline reference would then provide a mechanism for regulating construction activities in order to prevent turbidity from reaching an "unacceptable" level

The relationship between construction activity and turbidity is illustrated schematically by Figure 8. The significance of various levels is as follows:

- from Figure 6, the typical peak value under natural conditions is 10 JTU
- the extreme value on record is 51 JTU in the Columbia River at Cominco
- therefore, the range over which increased turbidity due to construction activity may be "acceptable" is between 0 and 50 JTU
- above 50 JTU, the turbidity due to construction activity could be increasingly "unacceptable" depending on the duration of the events
- the maximum level that Cominco can tolerate is unknown

The scope of this assignment, as noted in Section 4.1, is effectively limited to providing an overview because of the lack of site-specific data. In this regard, our assessment of the most probable scenario (in terms of the affect of declining water quality on the Cominco-Tadanac-Warfield water supply system) is that construction would have a minor impact - provided that diversion and borrow pit activities are controlled.

5. AREA POPULATION INCREASE, AND IMPACT ON EXISTING WATER/WASTEWATER SYSTEMS

5.1 Introduction

B.C. Hydro expanded the scope of this assignment to provide the necessary overview with respect to the significance of increased water supply and wastewater treatment requirements resulting from population growth generated directly or indirectly by the Project.

This overview covers communities both upstream and downstream of the proposed damsite.

For the communities upstream of the dam, much of the required information on water and sewer systems is available in reports prepared previously by Kerr Wood Leidal Associates Ltd. These reports assess the capability of existing systems to provide for an increase in service population, and present plans for upgrading systems. (Ref. Nos. 9-12)

For the communities downstream of the dam, baseline information with respect to the adequacy of existing waterworks systems is summarized in Section 2 of this report. With respect to wastewater systems, the analysis is simplified by the fact that the communities of Trail, Warfield, Rivervale, Oasis and Rossland are presently served by a regional collection and treatment system. (Ref. No. 13)

5.2 Population Projections

Table 7 summarizes the population projections for the Castlegar/Trail area based on two scenarios:

TABLE 7: CURRENT & PROJECTED POPULATION FOR THE CASTLEGAR/TRAIL AREA*

YEAR	WITHOUT KEENLEYSIDE-MURPHY PROJECT	WITHOUT KEENLEYSIDE-MURPHY PROJECT	INCREASE DUE TO KEENLEYSIDE-MURPHY CREEK
1981	34,900	34,900	0
1986	33,500	34,507	7
1987	34,400	34,430	30
1988	33,300	35,368	68
1989	33,200	33,486	286
1990	33,100	33,688	588
1991	33,000	33,792	792
1992	33,000	33,563	563
1993	33,000	33,266	266
1994	33,000	33,066	66
1995	33,000	33,006	6
1996	33,000	33,000	0

* Source: Ref. No. 6

** Note that decrease between 1981 and 1986 is attributed to winding down of Cominco expansion program; and that subsequent increase is due to natural growth.

- without the Keenleyside-Murphy Creek Project
- with the Keenleyside-Murphy Creek Project

The key point to note is that at the peak of construction in 1991, the population increase attributable to the Murphy Creek Project is estimated to be in the order of 600. In Reference No. 6, it is estimated that about 160 of these people would seek accommodation in the surrounding communities whereas the balance would be housed in a construction camp.

The relative significance of this figure of 160 is summarized as follows:

- the total population presently residing in the Castlegar/Trail region is 34,900 (1981 estimate)

- the projected population level for 1991 without considering the Murphy Creek Project is 33,300 (i.e. 1600 less than the 1981 level)

- the only population increase would be that generated by the Project

- the figure of 160 people represents an increase of about 0.5 percent

It therefore seems reasonable to conclude that the region could easily accommodate this relatively minor increase in population. Furthermore, provided the increase was distributed over the region there would be no measurable impact on any one community.

The possible impact on individual communities is considered in more detail in the following sub-sections.

5.3 Downstream Water Supply Systems

The adequacy of the existing downstream water supply systems can be quickly assessed on the basis of the data summarized in Table 4.

Trail

The only community that has significant excess capacity is Trail. Key points to note with respect to population trends in Trail are as follows:

- the population has steadily declined between 1971 and 1981 (i.e. from 11,149 to 9,340 according to Census figures)
- during the same period, the dwelling unit density factor has dropped from 3.1 to 2.5 persons per unit
- this trend is projected to continue until 1988 before reversing itself as a result of Cominco's expansion program
- for 1996 (i.e. a 15 year planning horizon), the projected population level (according to Ref. No. 6) is approximately 10,000 (i.e. still less than the 1971 level)

It therefore seems reasonable to conclude that the addition of less than 200 people would not significantly impact on the existing Trail system.

It should also be noted that as the population of Trail has been declining, so apparently has peak day water usage. Between 1976 and 1980, the demand dropped from 6.8 to 5.3MGD as the population decreased from 9,980 to 9,340. The per capita usage correspondingly declined from 2970 Lpcd (660 gpcd) to 2540 Lpcd (565 gpcd).

The total capacity of the existing sources of supply is 44 megalitres per day (9.73MGD), as noted in Table 4. This is approximately equivalent to a population level of 15,000 based on a peak day per capita usage of 2900 Lpcd (650 gpcd); and to a population of 16,000 based on 2700 Lpcd (600 gpcd).

Oasis-Rivervale

Both communities are effectively at the saturation level of development, and the water supply systems are being utilized to full capacity.

Rather than being faced with an influx of population, however, there is more likely to be an outflow of people due to the close proximity of the two communities to the actual construction site. Therefore, the focus of attention should probably be on the impact that these people might have in re-settling elsewhere.

Tadanac-Warfield

The capability of these two communities to accept an increase in population is, in part, a function of the capacity of the existing water treatment plants.

At present, the Tadanac plant is operating below capacity; whereas water supply requirements in Warfield exceed the plant capacity. (It should be noted that the peak day water demand in Tadanac is only about 10 percent of that in Warfield.)

The community of Tadanac is relatively small, and has limited potential for additional development. No upgrading of the water supply system would be required to provide for any increase in water supply requirements.

With respect to Warfield, the need for the water treatment plant is primarily a function of the quality (in terms of turbidity) of the raw water supply. In other words - provided the turbidity is less than the public health requirement of 5 Jackson Turbidity Units, it is not essential that the Columbia River water be filtered (although it must be disinfected). Therefore, it is not necessarily critical that water supply requirements presently exceed the plant capacity.

In conclusion, then, it is unlikely that the possible increase in population attributable to the Murphy Creek Project could be significant by itself to justify expansion of the Warfield treatment plant.

Green Gables-Cutillo

The two existing water systems have a total of about 95 service connections. It is reported that, due to topographic constraints, saturation development might be in the order of 115 connections. In other words, these communities have a limited capability to accept an increase in population. It therefore seems unlikely that the Murphy Creek Project would have a significant impact.

It is of interest to note that Reference No. 2 recommended combining the two systems in order to provide an upgraded standard of supply. This upgrading would involve developing a second groundwater well to replace the existing Cutillo wells and to provide for the total projected water requirements; and constructing a 0.45 megalitre reservoir to provide balancing and fireflow storage.

The existing systems are effectively operating at capacity. The Green Gables groundwater well pump station, for example, has to pump for approximately 16 hours to supply the peak day demand.

Montrose-Beaver Falls-Fruitvale

The three existing systems are at best marginally adequate to provide for present water usage. Therefore, any significant increase in population will necessitate upgrading of the water supply capability of the area. It should be noted that the area reportedly has potential for major land development should the demand arise - that is, the number of serviced lots could possibly be increased from the present 1,400 to a saturation level of about 2,500.

Reference No. 2 recommended integrating the three systems and developing additional groundwater wells to provide for future water supply requirements.

5.4 Downstream Wastewater Systems

Greater Trail Region

Wastewater treatment in the Greater Trail region is the responsibility of the Regional District of Kootenay Boundary. The Regional District operates the Columbia Pollution Control Centre that is located in the Waneta Junction sector of Trail. This facility was completed in 1972 and serves Trail, Rossland, Warfield, Rivervale and Oasis.

Cominco and the former District of Tadanac do not presently dispose of domestic wastewater to the regional system, but did participate in the financing with the intention of connecting in the future.

The Columbia Pollution Control Centre provides physical treatment, and is sized for a population of 24,500.

The present population in the service area is less than 16,000. In other words, there is sufficient excess capacity at the treatment plant to provide for a 50 percent increase in population.

In conclusion, then, the projected increase in population attributable to the Murphy Creek Project would not have a measurable impact on the existing system of wastewater collection, treatment and disposal.

Beaver Creek Valley

Both Montrose and Fruitvale have community wastewater collection and treatment systems.

The treatment plant in Montrose was constructed in about 1968 and is an oxidation ditch.

The plant in Fruitvale was constructed in about 1976 and comprises aerated lagoons. The plant is sized for a population of 3,000.

There is no community system in Beaver Falls as houses are serviced by individual septic tanks. Similarly, houses located outside the Fruitvale municipal boundary are on septic tanks.

Green Gables-Cutillo

These two communities are serviced by individual household septic tanks.

5.5 Upstream Water Supply Systems

The communities located upstream of the Murphy Creek dam site are as follows:

- Castlegar
- Balfour-Robson-Raspberry
- Brilliant
- Blueberry-Fairview
- Ootischenia
- Genelle-China Creek

Background information on the existing water supply systems in these communities is summarized in Reference No. 12.

Objectives of the present review are three-fold:

- provide a brief description of each system
- comment on system adequacy in terms of population support capacity
- discuss plans for system upgrading in order to provide for population growth

It should be noted that in-depth studies (prepared by Kerr Wood Leidal Associates Ltd.) on community water supply systems in the Castlegar Region provide a useful reference source for population settlement purposes - that is, the studies identify alternative scenarios for various population levels that an area can support; as well, the studies present plans for servicing existing and projected future levels of population. (Ref. Nos. 9-11)

Castlegar

The $6 million New Arrow Lakes Water Supply System constructed during the period 1979-1981 provides supply to the City of

Castlegar. The system, comprising major pump stations, large diameter pipelines and storage reservoirs, is sized for the total projected water demands of a future population level of 9,600, plus an industrial park presently being constructed in Castlegar South. This figure of 9,600 compares with the B.C. Hydro projected level of 7,300 for the year 1996 (i.e. a 15 year planning horizon). The reported 1981 service population is approximately 6,700.

It should be noted that the design of the supply and feeder system is flexible, and that it can be relatively easily modified to provide additional capacity for either a much longer design horizon or an expanded service area.

It should also be noted that the City has sufficient land development capacity to almost double the existing population level.

In conclusion, then, the Castlegar waterworks system could relatively easily support part or all of the population increase or population relocation generated by the Murphy Creek Project.

Balfour-Robson-Raspberry

This grouping refers to the four communities located on the north side of the Columbia River across from Castlegar, and encompasses:

- the Balfour Subdivision to the west
- the Robson Irrigation District
- the Raspberry Irrigation District
- the East Raspberry Improvement District to the east

The Balfour system is operated and maintained by B.C. Hydro and consists of two approximately 40 m deep wells adjacent to the Columbia River, pumping groundwater to a 90000 litre (20,000 gallon) woodstave storage tank. The capacity ratings of the two wells are about 430 Lpm (113 USgpm) and 770 Lpm (204 USgpm) respectively.

The distribution system consists of a single 150mm diameter asbestos cement main laid alongside Broadwater Road which parallels the Columbia River, with all properties serviced fronting on this road. Approximately at the mid-point of the main a 150mm diameter connection leads up the hillside to the 90000 litre woodstave storage tank. A second branch main connects to the pumphouses on the river side of the road.

Both Robson and West Raspberry take water from a small diversion dam on Pass Creek at approximately El. 476.5 m. The dam and first section of 400mm diameter pipe are jointly owned, then the systems split.

The Robson Irrigation District line extends west toward the Balfour system, stepping down from 400mm to 150mm pipe along the route. The last house served on this system is adjacent to the last house on the Balfour system.

The Raspberry Irrigation District distribution system consists of a 150mm pipe loop and a number of smaller diameter (50, 75 and 100mm) branch pipes. The loop is connected to the joint Robson-Raspberry 400mm supply line, and the western half of the loop parallels the 300mm Robson Branch.

There is no community water supply system in East Raspberry, and individual households obtain water from various sources reported to include 4 or 5 very small private well systems.

The existing sources of supply for Balfour, Robson and West Raspberry have sufficient capacity to provide for the present and projected water demands of the area. The feeder and distribution systems are inadequate, however, to convey the required rates of flow from the sources to the demand centers.

Reference No. 11 recommended an integrated waterworks system serving all four communities. The plan was based on utilizing Pass Creek as the primary source of supply, and retaining the Balfour wells as a standby supply (or alternatively, developing a new well in the alluvial fan at the mouth of the creek).

The same report included as assessment of the development potential for Robson-Raspberry. A summary of the data is as follows:

COMMUNITY	NO. OF DWELLING UNITS		
	EXISTING	SATURATION	DESIGN
Robson	348	789	475
West Raspberry	81	110	110
East Raspberry	34	109	45
TOTALS	463	1008	630

The "design" figure of 630 is based on a 1996 planning horizon (i.e. 15 years) and corresponds to an equivalent annual growth rate of 2 percent. (Note that in water supply planning, a practical upper limit for most areas in terms of a "planning horizon" is in the order of 10 to 15 years).

The significance of the above data is that it indicates the capability of the Robson-Raspberry area to provide for population growth that may result from increased economic activity and development within the surrounding region. In this regard, it should be noted that the Robson-Raspberry sub-region has been designated as a "primary settlement area" within the context of the Arrow Lakes Regional Plan.

Also noteworthy, the Balfour system has about 45 service connections; with a number of unoccupied lots as well as a trailer court which could be added to the water distribution system.

Brilliant

Brilliant is located due east of Raspberry on the floodplain at the confluence of the Kootenay and Columbia Rivers.

The waterworks system consists of three private systems integrated with a community system. The pipe network is mainly 100mm.

A community well supplies water to 21 properties and the cultural centre. Three private well systems supply another 25 homes.

The community well was drilled in 1965, has a rated capacity of 1300 lpm (350 US gpm), and feeds 4 self-pressurizing tanks, each with a capacity of approximately 2300 litres (500 gallons).

It is reported that there are potentially about another 19 lots in Brilliant which could be developed.

Previous studies have investigated the feasibility of Brilliant participating in a regional water supply project. However, it has been concluded that the costs far exceed the benefits due to the relatively remote location of the community. In addition, the residents of Brilliant have expressed their intention to remain independent.

Blueberry-Fairview

The communities of Blueberry and Fairview are located due south of Castlegar.

The Blueberry water source is based on surface gravity supply from Blueberry Creek with an intake at approximately El. 512.8 m. The water is conveyed via a 200mm main to the community distribution system, the latter consisting mainly of 100mm AC piping, but also including some 150mm and 50mm piping.

Water supply for the Fairview Subdivision (also known as the Poupore Improvement District) is obtained from two small springs known as Petersen and Mads Brook. The system consists of a 100mm PVC watermain and a steel fiberglassed tank with 90000 litre (20,000 gallons) storage capacity.

Reference No. 10 recommended an integrated waterworks system serving the Blueberry-Fairview region, based on developing a groundwater well at the mouth of Blueberry Creek as a supplementary and/or replacement source for the existing surface water supplies.

The same report included an assessment of the development potential for Blueberry-Fairview and the surrounding unorganized territory.

A summary of the data is as follows:

COMMUNITY	NO. OF DWELLING UNITS		
	EXISTING	SATURATION	DESIGN
Blueberry	207	240	240
Fairview	39	55	50
Unorganized Territory	-	150	60

It should be noted that the existing sources of supply are presently being utilized to capacity; and that any further land development will be contingent upon implementing the plan for regional water supply.

Ootischenia

Ootischenia is located on a bench on the east side of the Columbia River across from Castlegar.

Water supply in Ootischenia is based on two marginally adequate groundwater wells with capacities in the order of 1060 Lpm (280 USgpm) and 1130 Lpm (300 USgpm), respectively.

It is also understood that supplementary water supplies are obtained from a number of creeks in the District including Iron, Cai, Airport, Ootischenia and Phillipps Creeks.

Over two years ago a new high capacity groundwater well was developed adjacent to Selkirk College, and it is probable that it may be incorporated into the Ootischenia system in accordance with the recommended plan for water supply as presented in Reference No. 9.

The number of dwelling units served by the waterworks system is approximately 160. This compares with a total of 282 lots within the service area. In other words, there is significant potential for further development - provided the capacity of the water supply system is increased.

Genelle-China Creek

Water supply to Genelle-China Creek is based on two sources - a surface gravity supply from China Creek, and a recently constructed groundwater well located within the lower bench area subdivision. The system includes an open reservoir and distribution mains comprising 150 and 100 mm pipe. The well capacity is reported as about 950 Lpm (250 USgpm). The system serves approximately 200 dwelling units.

5.6 Upstream Wastewater Systems

The only community upstream of the Murphy Creek dam site that has a wastewater collection and treatment system is the City of Castlegar. In all other communities existing development is presently serviced by individual septic tanks. (It should be noted, however, that a collection and treatment system was proposed for Robson-Raspberry in Reference No. 11.)

Castlegar is served by two wastewater collection and treatment systems: the North system was constructed in the mid-1960's, while the South system was completed in 1976.

The North wastewater treatment plant is located on the north side of the Columbia River on the old Celgar sawmill site, and comprises two aerated lagoons, a polishing cell and chlorination facilities. Discharge is by an outfall to the Columbia River.

The original design of the lagoon system was based on a design population of 3500 people and an average daily wastewater load of 1.58 megalitres per day (350,000 gpd).

As a result of an expansion program completed a few years ago, the design capacity has been increased to a reported 2.70 megalitres per day (600,000 gpd). Based on the City's present average dry weather flows of 270 Lpcd (60 gpcd), this is equivalent to a population capacity of 10,000.

Sewage is conveyed to the north treatment facility by a gravity interceptor located on the CPR bridge crossing the Columbia River. The collector and trunk system includes four sewage pumping stations servicing localized low level areas.

The South wastewater treatment plant is located off Connors Road just north of both Highway 3A and the CP railway. The plant is an activated sludge facility that consists of a 24.4m diameter concrete tank fitted internally with partitions to form separate compartments. The plant has been designed to operate on the extended aeration principle until the population served exceeds about 4,000 people, at which point conventional loading may be adopted. With an ultimate average daily design flow of 2.25 megalitres per day (500,000 gpd), the system capacity is in the order of 7,000 to 8,000.

The interceptor system parallels the CPR right-of-way for much of its route. One sewage pumping station-forcemain system serves a relatively small subdivision development located on a low-lying bench area adjacent to the river.

In summary, the existing treatment plants have sufficient capacity to provide for at least a doubling of the present population. Therefore, they could relatively easily support part or all of the population increase that may be generated by the Murphy Creek Project.

5.7 Summary

At the peak of construction of the proposed Murphy Creek Project, it is estimated that the Project would result in a total population increase of about 600. However, the majority of the in-migrant workforce would be housed in a B. C. Hydro construction camp. Therefore, the net population increase that would have to be absorbed by communities in the Castlegar/Trail Region might only be about 160. Based on past history in the West Kootenays, the workforce could be further dispersed to areas such as Rossland, the Slocan Valley, Salmo and Nelson.

It seems reasonable to conclude that, considered as a whole, the region could easily accommodate this minor increase in population. Depending on off-site settlement/re-settlement considerations, however, there may possibly be an impact on several of the smaller water/wastewater systems that are at best marginally adequate - but only in the unlikely event that off-site settlement of in-migrant workers and relocation of those people directly impacted by the Project was concentrated in one locale.

Downstream Water/Wastewater Systems

Table 8 has been prepared in order to summarize the key information presented in the foregoing sections with respect to the capacities of existing water supply and wastewater systems in communities located downstream of the Murphy Creek Project.

The information is presented in terms of both dwelling units and population.

With respect to water supply, the key points are:

- the Trail system is the only one with significant extra capacity to provide for a major population increase

- this is mainly attributable to the fact that the population has declined by almost 2000 during the last 10 year period; and that the Waneta well has recently been incorporated into the system

- other systems are typically marginally adequate for the existing population, and would require major upgrading to provide for any significant population increase

With respect to wastewater, the key points are:

- community sewer systems exist in all incorporated communities (i.e. cities and villages)

- the Columbia Pollution Control Centre in Trail provides wastewater treatment for Oasis, Rivervale, Trail, Warfield and Rossland

- this facility is presently operating at about 65% of capacity, and therefore can provide for a major population increase

- the villages of Montrose and Fruitvale both have treatment plants that have capacity surplus to present day requirements

Upstream Water/Wastewater Systems

Table 9 has been prepared in order to summarize the key information with respect to the capacities of existing water supply and wastewater systems in communities located upstream of the Murphy Creek Project.

With respect to water supply, the key points are:

- existing sources generally have capacity in excess of present supply requirements

- the exceptions are Blueberry and Fairview which have source problems

- the Castlegar system is the only one with the delivery capability to provide for a major population increase

- other systems typically have hydraulic capacity constraints, and would require major upgrading to provide for any significant population increase

It must be emphasized that the "source problems" and "hydraulic capacity constraints" referred to above represent existing system limitations, and are unrelated to the Murphy Project.

With respect to wastewater, only the City of Castlegar has a community sewer system and treatment facilities. All other communities have individual household septic tanks.

TABLE 8 - SUMMARY OF WATER/WASTEWATER SYSTEM CAPACITIES FOR DOWNSTREAM COMMUNITIES Page 1 of 2

COMMUNITY	PRESENT DEVELOPMENT DWELLING UNITS	PRESENT DEVELOPMENT POPULATION	WATER SUPPLY SYSTEM CAPACITY DWELLING UNITS	WATER SUPPLY SYSTEM CAPACITY POPULATION	WASTEWATER SYSTEM CAPACITY DWELLING UNITS	WASTEWATER SYSTEM CAPACITY POPULATION	COMMENTS
Oasis	36	160	36	160	-	(24,500)*	- community already at saturation development - no excess capacity in water supply system
Rivervale	110	280	110	280	-	(24,500)*	- community already at saturation development - no excess capacity in water supply system
Tadanac	74	200	100	270	-	(24,500)*	- water treatment plant has surplus capacity
Warfield	730	2050	-	1650	-	(24,500)*	- existing water filtration plant has capacity to provide for perhaps 80% of present peak day demand
Trail	3810	9600	-	15000	-	(24,500)*	- water supply system has surplus capacity
Cutillo	15	50	15	50	-	-	- no community sewer system - water system effectively operating at capacity - land development potential is limited to perhaps 5 units
Green Gables	80	250	80	250	-	-	- no community sewer system - water system effectively operating at capacity - land development potential is limited to perhaps 15 units
Montrose	370	1229	370	1195	-	-	- information on wastewater treatment plant capacity not available - water supply system requires upgrading to provide for populatio increase - land development potential is perhaps 500 lots (i.e. an increase of 130)
Beaver Falls	200	640	200	640	-	-	- water supply system requires upgrading to provide for population increase - land development potential is perhaps 285 lots - no community sewer system

TABLE 8 - SUMMARY OF WATER/WASTEWATER SYSTEM CAPACITIES FOR DOWNSTREAM COMMUNITIES Page 2 of 2

COMMUNITY	PRESENT DEVELOPMENT		WATER SUPPLY SYSTEM CAPACITY		WASTEWATER SYSTEM CAPACITY		COMMENTS
	DWELLING UNITS	POPULATION	DWELLING UNITS	POPULATION	DWELLING UNITS	POPULATION	
Fruitvale							
(a) Waterworks District	800	2560	800	2560	-	-	- water supply system requires upgrading to provide for any population increase
(b) Village	580	1850	-	-	940	3,000	- land development potential is perhaps as many as 1600 lots (i.e. an increase of 800) - water and sewer systems serve different areas

* Design capacity of regional wastewater treatment facility is equivalent to 24,500 population; facility is presently operating at about 65% of capacity, and serves Rossland in addition to the above noted communities.

TABLE 9 - SUMMARY OF WATER/WASTEWATER SYSTEM CAPACITIES FOR UPSTREAM COMMUNITIES   Page 1 of 2

COMMUNITY	PRESENT DEVELOPMENT		WATER SUPPLY SYSTEM CAPACITY		WASTEWATER SYSTEM CAPACITY		COMMENTS
	DWELLING UNITS*	POPULATION**	DWELLING UNITS	POPULATION	DWELLING UNITS	POPULATION	
Balfour	45	140	500	500			- no community sewer system - capacity rating of wells assumes maximum 16 hours operation per day during periods of peak demand
Robson	348	1050	(2,500)	(7,500)	-	-	- the population support capacity of the existing source of supply for Robson and West Raspberry is 2500 d.u.; this compares with a saturation development level of 900 units - the existing waterworks system, however, is already inadequate to convey the peak day demand - no community sewer system
West Raspberry	81	250	(2,500)	(7,500)	-	-	- (as above)
East Raspberry	34	100	-	-	-	-	- no community water or sewer systems - land development potential is perhaps 100 lots
Brilliant	46	140	150	500	-	-	- no community sewer system - land development potential is perhaps 19 more lots - capacity rating is for community well
Castlegar	2,300	6,720	3,200	9,600	3,300 2,000	10,000(N) 6,000(S)	- two treatment plants: lagoons in the North; activated sludge facility in the South - the water supply system can be easily modified to support a larger population - land development potential could support double the population
Blueberry	207	620	220	660	-	-	- water quality problems associated with logging and highway threaten the Blueberry Creek source of supply - no community sewer system - land development potential is perhaps 240 lots
Fairview	39	120	39	120	-	-	- no community sewer system - sources of water supply are marginal - moratorium on development - land development potential is 55 lots

TABLE 9 - SUMMARY OF WATER/WASTEWATER SYSTEM CAPACITIES FOR UPSTREAM COMMUNITIES Page 2 of 2

COMMUNITY	PRESENT DEVELOPMENT		WATER SUPPLY SYSTEM CAPACITY		WASTEWATER SYSTEM CAPACITY		COMMENTS
	DWELLING UNITS*	POPULATION**	DWELLING UNITS	POPULATION	DWELLING UNITS	POPULATION	
Ootischenia	160	480	200	600	-	-	- no community sewer system - capacity rating of wells assumes maximum 16 hours operation per day, and allows for irrigation requirements - waterworks system has limited hydraulic capacity
Genelle-China Creek	200	650	200	650	-	-	- no community sewer system

* Based primarily on data compiled for previous water studies.

**Based on applying a dwelling unit factor of 3.0 persons per unit.

PART C - CONCLUSIONS AND RECOMMENDATIONS

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6. CONCLUSIONS

The assessment of the potential impact of the proposed Murphy Creek Project on existing and potential downstream waterworks systems has focused mainly on these two matters:

- changes in turbidity in the Columbia River during construction, and the implications with respect to Cominco's industrial operation at Trail
- increased domestic water supply requirements related to the Project workforce, and the significance with respect to existing system capacities

Based on the information presented in the summary sub-section in each of the foregoing sections, the key conclusions regarding downstream water works systems are as follows:

1. The only system that could possibly be directly affected by suspended sediment from construction activities is the Cominco-Warfield-Tadanac system (this is the major system in the region).
2. The proposed "in the dry" method of dam construction would be relatively controlled, and should minimize sediment discharge to the river.
3. Construction activities (e.g. borrow pit operations) could potentially generate significant quantities of sediment; this necessitates developing an erosion and sediment control plan for containing the sediment at at the source.
4. The probability of exceeding maximum levels of turbidity and suspended sediment recorded previously is low.

5. Prior to construction, a turbidity and suspended sediment monitoring program is required in order to establish a baseline reference on natural river conditions.

6. Provided overall levels of turbidity and suspended sediment do not exceed the maximum levels experienced previously (e.g. 50 JTU for turbidity), there will be no measurable impact on Cominco's operations.

7. With regard to the existing Tadanac water treatment plant, the capability of this facility to handle increasingly turbid water could be extended by a relatively straightforward modification to the filtration process.

8. The net population increase attributable to the Project is insignificant relative to the Castlegar/Trail regional population.

9. Due to some decline in population over the past decade in Trail, it is the one downstream waterworks system with significant extra capacity to provide for any concentrated population increase related to the Project workforce.

10. The capacities of other community systems are typically only marginally adequate for the existing population.

In addition to downstream water use, the study has also included a review of the population support capacities of upstream waterworks systems, as well as the support capacities of both upstream and downstream wastewater systems. This information may prove useful in the socio-economic planning process for the Murphy Creek Project should a population settlement/re-settlement strategy be required for the Castlegar/Trail Region.

7. RECOMMENDATIONS

Based on the findings presented herein, it is recommended that:

1) a turbidity and suspended sediment monitoring program be implemented prior to construction

2) a suspended sediment sampling station be located downstream of the damsite to replace the existing station at Birchbank

3) as part of the monitoring program, Cominco be requested to reactivate the existing turbidimeter in the Tadanac W.T.P. and/or install a turbidimeter in the Stoney Creek Pump Station

4) the monitoring program be continued during construction in order to provide a mechanism for evaluating the impact of construction activities

5) an 'off-site' sediment containment plan be implemented in borrow-pit areas

Further to Item No. 4, it should be noted that continuing the monitoring program during construction would have a twofold significance:

- if suspended sediment levels were well below a predetermined threshold level, then this would provide a 'margin of safety' for construction activities
- if suspended sediment levels were approaching a specified upper limit, then construction activities could be curtailed until conditions in the river stabilized, with subsequent minor alterations in the construction method

The objective of a monitoring program would be to prevent suspended sediment levels from increasing to the critical point where curtailment of construction activities would be necessary in order to avoid impact on Cominco operations.

Further to Item No. 5, a sediment containment plan should include the following basic control measures:

- vegetated buffer zones downslope of the work areas to slow and filter runoff
- small depressions or dikes to catch sediment as close to its point of origin as possible
- settling basins at the perimeter of the site to capture additional sediment from runoff

The objective of this plan would be to minimize and control the impact of sediment discharges into receiving waterways.

PART D - APPENDICES

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1. TERMS OF REFERENCE

2. LIST OF REFERENCES

APPENDIX 1

TERMS OF REFERENCE

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

TERMS OF REFERENCE
FOR
ENVIRONMENTAL STUDIES
FOR THE
PROPOSED MURPHY CREEK
HYDROELECTRIC PROJECT

April 1981

SYSTEM ENGINEERING DIVISION

TERMS OF REFERENCE
FOR ENVIRONMENTAL STUDIES FOR THE PROPOSED
MURPHY CREEK HYDROELECTRIC PROJECT

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1.0 INTRODUCTION

These Terms of Reference are for detailed ecological and socio-economic studies, called the "Studies", which are required for environmental impact evaluation of a potential hydroelectric development by the British Columbia Hydro Electric and Power Authority (B.C. Hydro) on the Columbia River in the vicinity of Murphy Creek.

Prior to signing the Columbia River Treaty in 1961 and its ratification in 1964, numerous studies were made of the hydroelectric development of the Columbia River in Canada. The Treaty between the United States and Canada led to the construction of Mica, Hugh Keenleyside and Duncan projects in Canada. Other major hydroelectric projects in the Columbia River basin in Canada include the Kootenay Canal project completed in 1975, and the Seven Mile and Revelstoke projects which are under construction.

The potential of the Murphy Creek site was first identified in 1956. Consideration of the development of the project was more recently given during the 1972 B.C. Energy Board studies. Subsequently, preliminary engineering and environmental studies were carried out in 1977 and 1978, to examine the project potential at a prefeasibility level and to identify probable environmental impacts.

The Murphy Creek site is located on the Columbia River approximately 3 km upstream of the city of Trail and 25 km downstream of the confluence of the Columbia and Kootenay rivers. The tentative layout for the project consists of an earthfill dam, approximately 33 m high, extending across the river from the left bank to a concrete spillway and 10-unit powerhouse located on the right bank. A total installed capacity of 400 MW would be provided by ten 40 MW turbine generators.

In early 1979 a preliminary study of the residential, commercial and industrial properties that may be affected by the

1.0 INTRODUCTION - (Cont'd)

project was undertaken by the Properties Division. An engineering feasibility study scheduled for completion by the end of 1980 is in progress.

All field work associated with the Studies outlined in these Terms of Reference is scheduled for completion in 1980 where possible, in order that environmental impacts may be properly assessed by mid-1981. The engineering feasibility study associated with the project is being carried out by the Hydroelectric Generation Projects Division of B.C. Hydro, who will also be responsible for several aspects of the Studies such as geology, hydrology and river morphology.

2.0 STUDIES AREA

The Studies area consists of all lands on either side of the Columbia River from the axis of the proposed dam in the vicinity of Oasis, upstream to the Hugh Keenlyside dam on the Columbia River, and to the Brilliant dam on the Kootenay River, up to an elevation of 500 m. Studies may extend beyond this area in specific cases where considered necessary.

Some areas outside these limits will be studied for socio-economic impacts from both the construction work force and the operating staff.

3.0 STUDIES OBJECTIVES

1. To provide an inventory of environmental resources that could be impacted by the potential project within the Studies area. This will be compiled from on-site investigations and other available sources.

2. To provide a qualitative and quantitative evaluation of impacts, both adverse and beneficial, which would result from the potential project.

3.0 STUDIES OBJECTIVES - (Cont'd)

3. To provide an evaluation of resource losses and gains in monetary terms for inclusion in a benefit-cost analysis.

4. To provide an evaluation of opportunities for practical mitigation and compensation measures which would avoid or reduce adverse impacts created by the development.

5. To provide data which could be needed for preparation of an Environmental Impact Statement for the potential project.

4.0 STUDIES ORGANIZATION

(a) Co-ordination

The entire program will be directed and co-ordinated either by B.C. Hydro, or by B.C. Hydro assisted by a prime consultant. Under this direction, certain disciplines of the Studies will be carried out by B.C. Hydro staff or by consultants. Technical responsibility within individual disciplines will rest with the B.C. Hydro staff or with respective consultants. B.C. Hydro or its prime consultant will assume the role of co-ordinating the individual disciplines during the Studies period and during the preparation of the final report.

Consultants should liaise with the appropriate government agencies both before and during their studies to ensure that full use is made of existing available information and knowledge.

Consultants, subconsultants and their staff shall co-operate with all other consultants hired by B.C. Hydro for the same or similar projects, and on request by B.C. Hydro shall make available to such consultants all material gathered or produced for this project.

4.0 STUDIES ORGANIZATION - (Cont'd)

B.C. Hydro has an ongoing Community Relations program associated with this project. All contact with outside agencies and the public shall be co-ordinated with the Community Relations program through B.C. Hydro. B.C. Hydro should be advised in advance of the need for any formal contact with local or regional governments and the public.

(b) Studies Sections

The Studies shall be organized into four groups: Physical Resources, Terrestrial Resources, Aquatic Resources and Socio-economic. Each group is composed of closely related subjects called "Sections" A to O, as follows:

Physical Resources

A Geology and Landforms
B Hydrology and River Morphology
C Water Quality
D Climate

Terrestrial Resources

E Agriculture
F Vegetation
G Forestry
H Wildlife

Aquatic Resources

I Fish and Aquatic Habitats

4.0 STUDIES ORGANIZATION - (Cont'd)

Socio-economic

J	Regional Economy and Human Communities
K	Recreation and Tourism
L	Heritage Resources
M	Resource Analysis
N	Land Use
O	Downstream Water Use

5.0 STUDIES METHODOLOGY

Evaluation of the environmental impact of the project shall take into consideration all project actions associated with the development. These shall include pre-project activities such as field investigation or land acquisition; construction activities such as site and reservoir clearing, dam, powerhouse and road construction, construction camp activities; and operation and maintenance of the powerplant. Project descriptions will be provided by B.C. Hydro.

Definition and development of all methodologies for the Studies should be made early in the program and provided to B.C. Hydro for their approval. This may include the use of various impact matrices, mapping techniques, economic analyses, etc. The methodology for evaluation in each of the Sections shall be consistent with criteria selected for the evaluation of the environmental impact. Special attention shall be directed to providing information suitable for inclusion in a benefit-cost analysis of mitigation and compensation alternatives.

The following is provided by B.C. Hydro to give direction on the scope of the Studies:

1. All resources and their significance, with and without the project, on a local, regional and provincial scale based upon present value and potential value.

5.0 STUDIES METHODOLOGY - (Cont'd)

2. Environmental impacts including:

   a. Primary, secondary and induced impacts.

   b. Beneficial and adverse effects.

3. Distributional aspects of impacts including:

   a. Geographical - local, regional, provincial and international.

   b. Social - impacts on various segments of the population, ethnic or special interest groups.

   c. Transfer of resource demands to other locations.

4. Probability of occurrence of an impact and reasons for uncertainty of the impact's occurrence.

5. Expected time and duration of an impact occurrence. A distinction shall be made between short-term impacts (those which last for the construction period only) and long-term impacts (those which persist after construction).

6. Possible benefits, both short and long-term, of all compensation and mitigation measures.

7. The costs associated with all compensation and mitigation measures.

8. Relationship between project impacts and long-term regional development prospects shall be evaluated.

All sources of data, information and references shall be thoroughly documented.

6.0 REPORTING PROCEDURES

Written reports will be required for all Sections of the Studies. The number of copies of such reports will be established at the time study proposals are called for. Prior to the preparation of these reports, consultants will be required to submit a report outline to B.C. Hydro for review and approval. Subsequently, draft reports will be prepared and submitted for review and approval by B.C. Hydro and, where necessary, by outside experts before they are accepted. All final reports shall be in a form suitable for release to government agencies and the public.

Following completion of all the reports for the Sections, B.C. Hydro or its prime consultant will prepare an integrated summary report in consultation with the authors of the Sections and outside experts, where necessary. This report will be the final report of the Studies.

7.0 STUDIES SCHEDULE

The Studies will be undertaken in 1980 and possibly beyond. A target schedule showing specific deadlines will be issued for each Section.

8.0 STUDIES SECTIONS

The following are guidelines for each of the Sections. These guidelines distinguish between inventory and assessment work and, where feasible, this distinction should be made in report preparation.

SECTION O

DOWNSTREAM WATER USE

(a) INVENTORY

Carry out field investigations and office studies to provide an inventory of knowledge of existing Columbia River water users and tributary water users in those areas where project activities could occur (such as Hanna and Billy creeks), in the area between the proposed Murphy Creek Dam Site and the US/Canada border. This will cover but not be limited to:

1. The number, type (description) and location of consumptive domestic, commercial, community water facilities users. This inventory will also determine those users/user facilities which are dependent upon existing river fed ground water.

2. Data sources to be evaluated include municipal, provincial and the federal government agencies, regional districts and community/commercial concerns.

3. Document public and commercial concerns with respect to water use.

(b) EFFECTS OF DEVELOPMENT

Make an assessment of the potential impact of the proposed development on the existing and potential downstream water users/user facilities below the Dam Site.

1. Recommendations should be made towards alternative mitigation/compensation measures which could entail preparation of alternative plans for water supply (either on an interim or permanent basis), preparation of capital cost estimates and a discussion of the strategies for implementation.

2. Quantitative data on water quality/quantity will be utilized wherever appropriate to the assessment of the effect of the development.

3. Assess public and commercial concerns with respect to the effect of the development.

APPENDIX 2

LIST OF REFERENCES

LIST OF REFERENCES

The following reports have been used as reference sources:

° Ref. No. 1 - *Columbia River-Murphy Creek Project: Engineering Description*, prepared by B. C. Hydro, Hydroelectric Generation Projects Division, November 1982 (Report No. H1565)

° Ref. No. 2 - *Montrose/Fruitvale Area Water Study*, prepared by Underwood McLellan Ltd., November 1980

° Ref. No. 3 - *Murphy Creek Environmental Assessment Water Quality Study*, prepared by I.E.C., International Environmental Consultants Ltd., June 1981

° Ref. No. 4 - *Murphy Creek Project Environmental Setting, Hydrology, River Morphology and Climate*, prepared by B. C. Hydro Hydroelectric Generation Projects Division, February 1981 (Report No. H1350)

° Ref. No. 5 - Correspondence between Kerr Wood Leidal Associates Ltd. and Cominco during the period June/July 1981.

° Ref. No. 6 - *Keenleyside-Murphy Project Socio-Economic Assessment*, prepared by DPA Consulting Ltd., 1983

° Ref. No. 7 - *Trail Waterworks Survey*, prepared by Dayton & Knight Ltd., November 1968

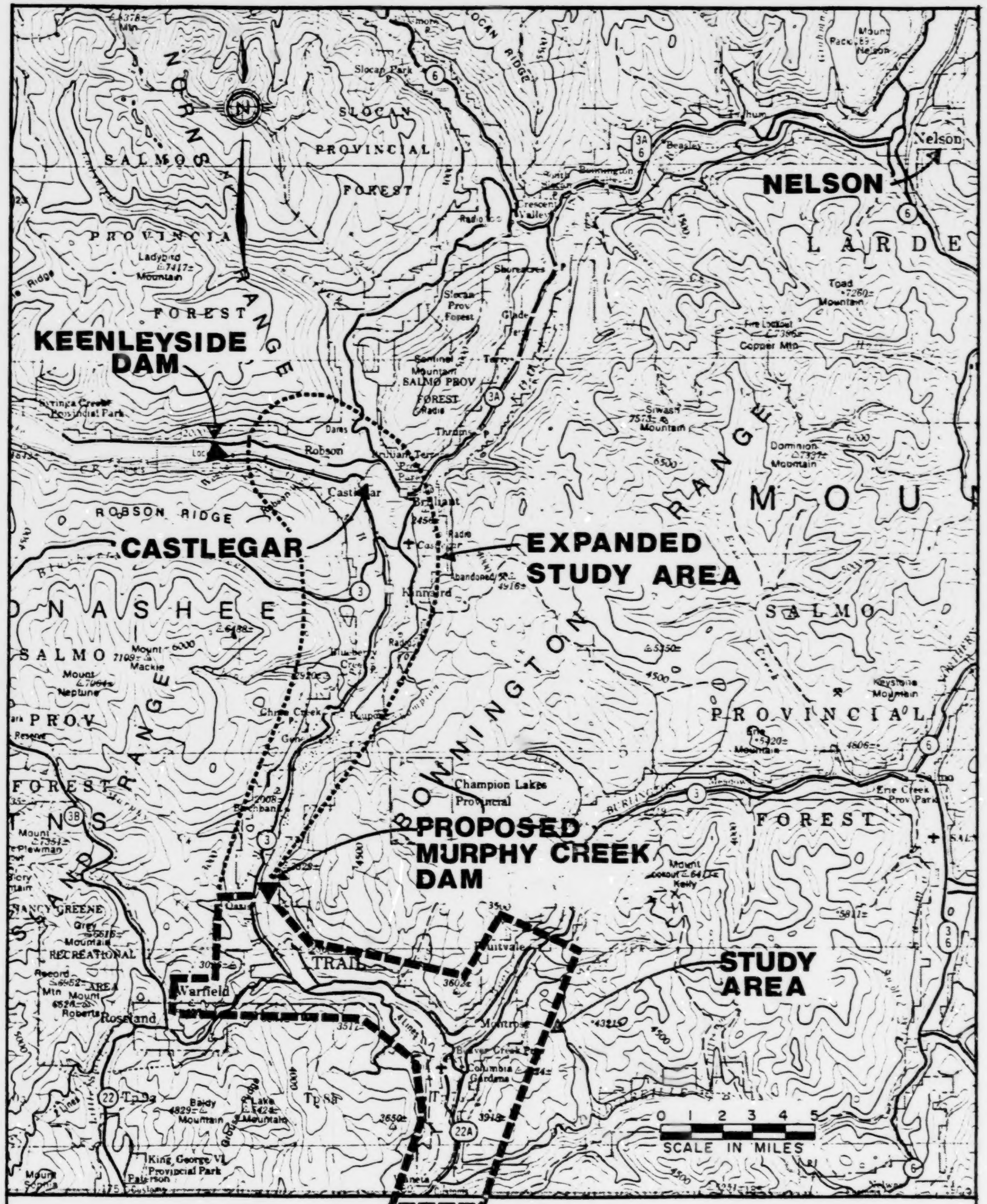
° Ref. No. 8 - *Murphy Creek Project Preliminary Design Groundwater Studies*, prepared by Pacific Hydrology Consultants Ltd., August 1982

° Ref. No. 9 - *Report on Water Supply for the Castlegar Region*, prepared by Kerr Wood Leidal Associates Ltd., September 1977

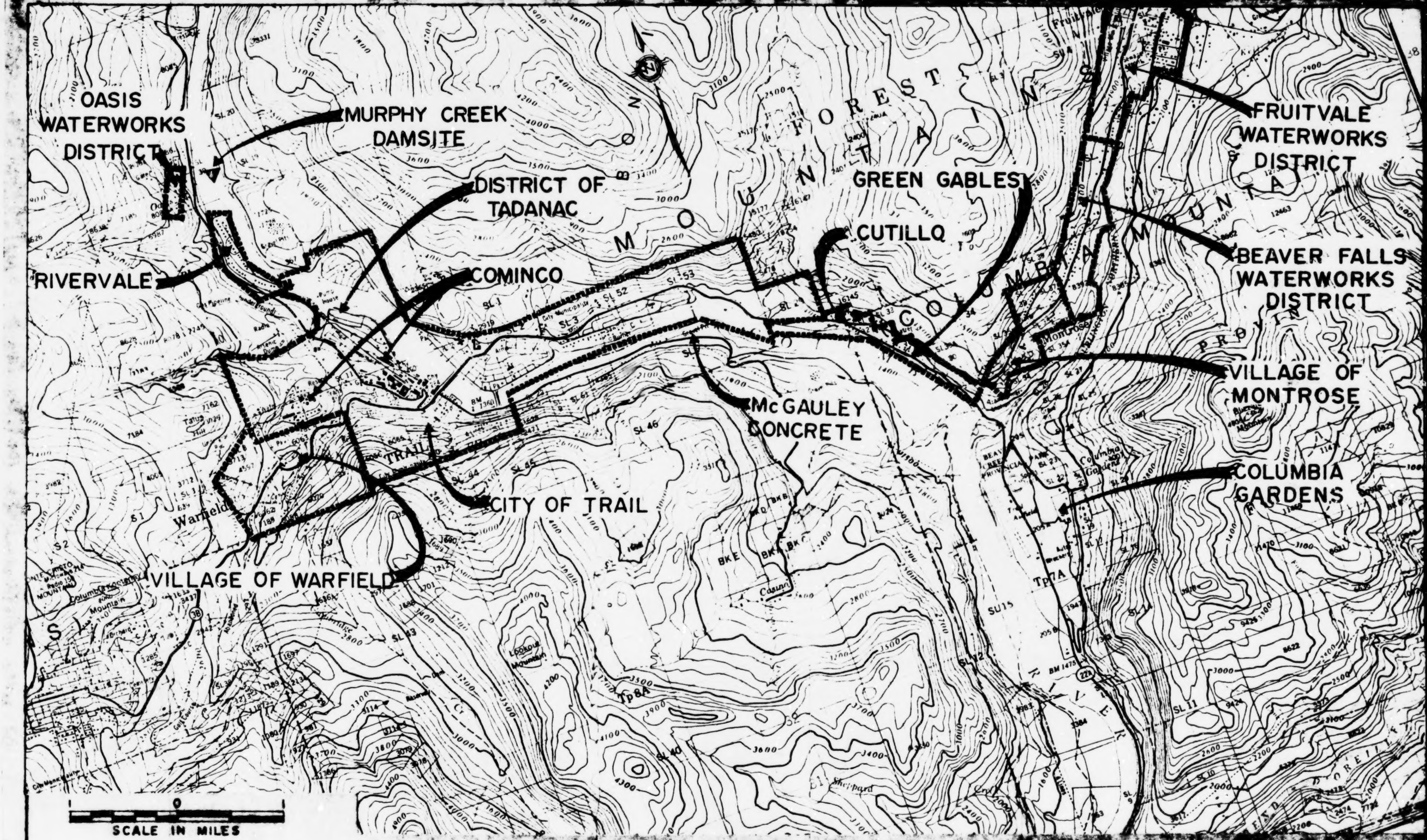
° Ref. No.10 - *Report on Water Supply for the Blueberry-Fairview Region*, prepared by Kerr Wood Leidal Associates Ltd., October 1980

° Ref. No.11 - *Report on Water and Wastewater for the Robson-Raspberry Region*, prepared by Kerr Wood Leidal Associates Ltd., January 1981

- Ref. No. 12 - *Phase 1 Inventory Study, Impact of the Murphy Creek Project on Municipal Services in the Castlegar Region*, prepared by Kerr Wood Leidal Associates Ltd., February 1981
- Ref. No. 13 - *Oasis-Rivervale Sewerage Survey*, prepared by Dayton & Knight Ltd., February 1975

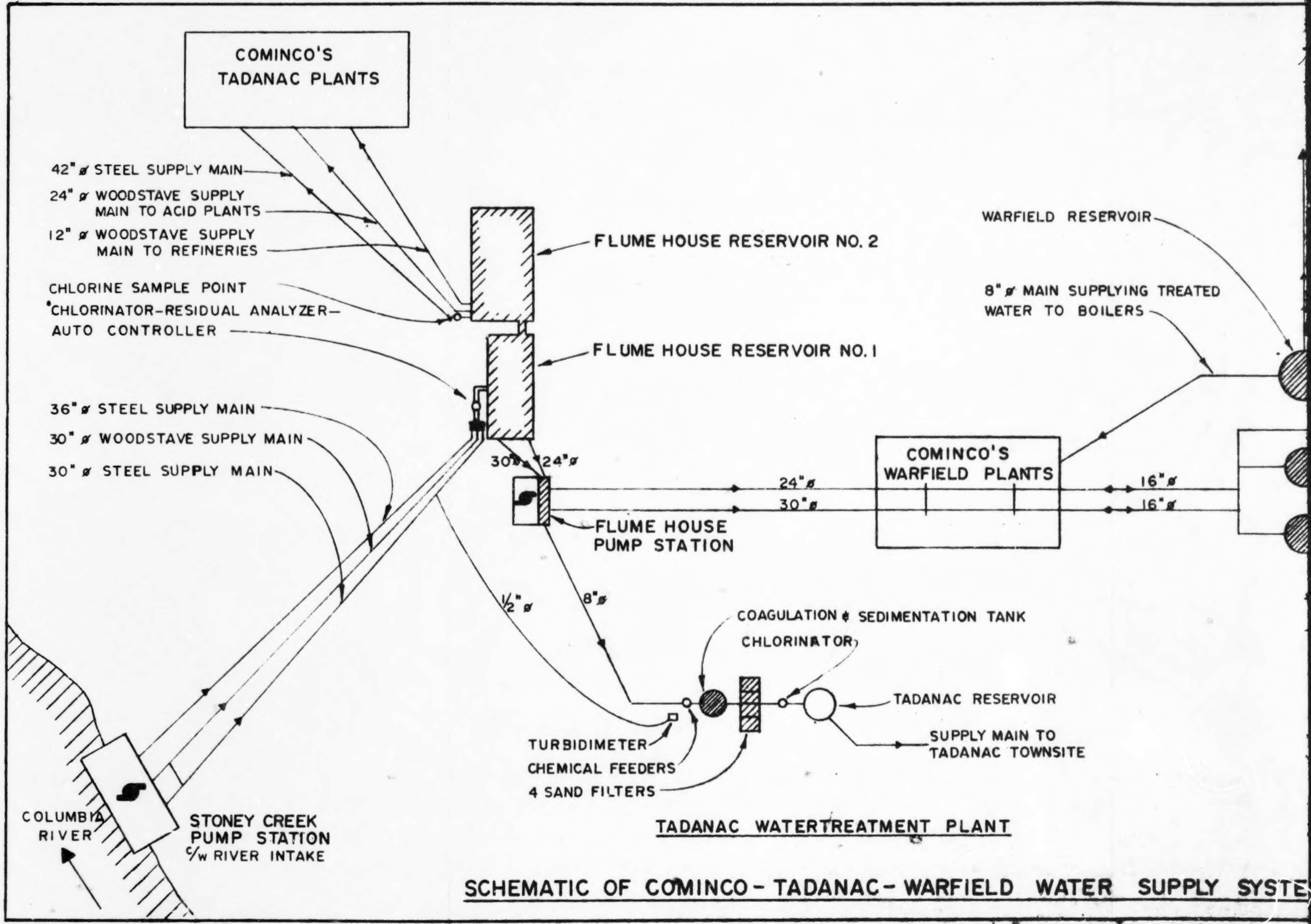

KEENLEYSIDE DAM
CASTLEGAR
NELSON
EXPANDED STUDY AREA
PROPOSED MURPHY CREEK DAM
STUDY AREA
TRAIL
Warfield
Rossland
Montrose
Fruitvale
Robson
Brilliant
Kinnaird
Slocan Park
SLOCAN PROVINCIAL FOREST
SALMO PROVINCIAL FOREST
BONNINGTON RANGE
NORNS RANGE
ROBSON RIDGE
NASHEE
Champion Lakes Provincial
0 1 2 3 4 5
SCALE IN MILES

LOCATION MAP FIGURE 1

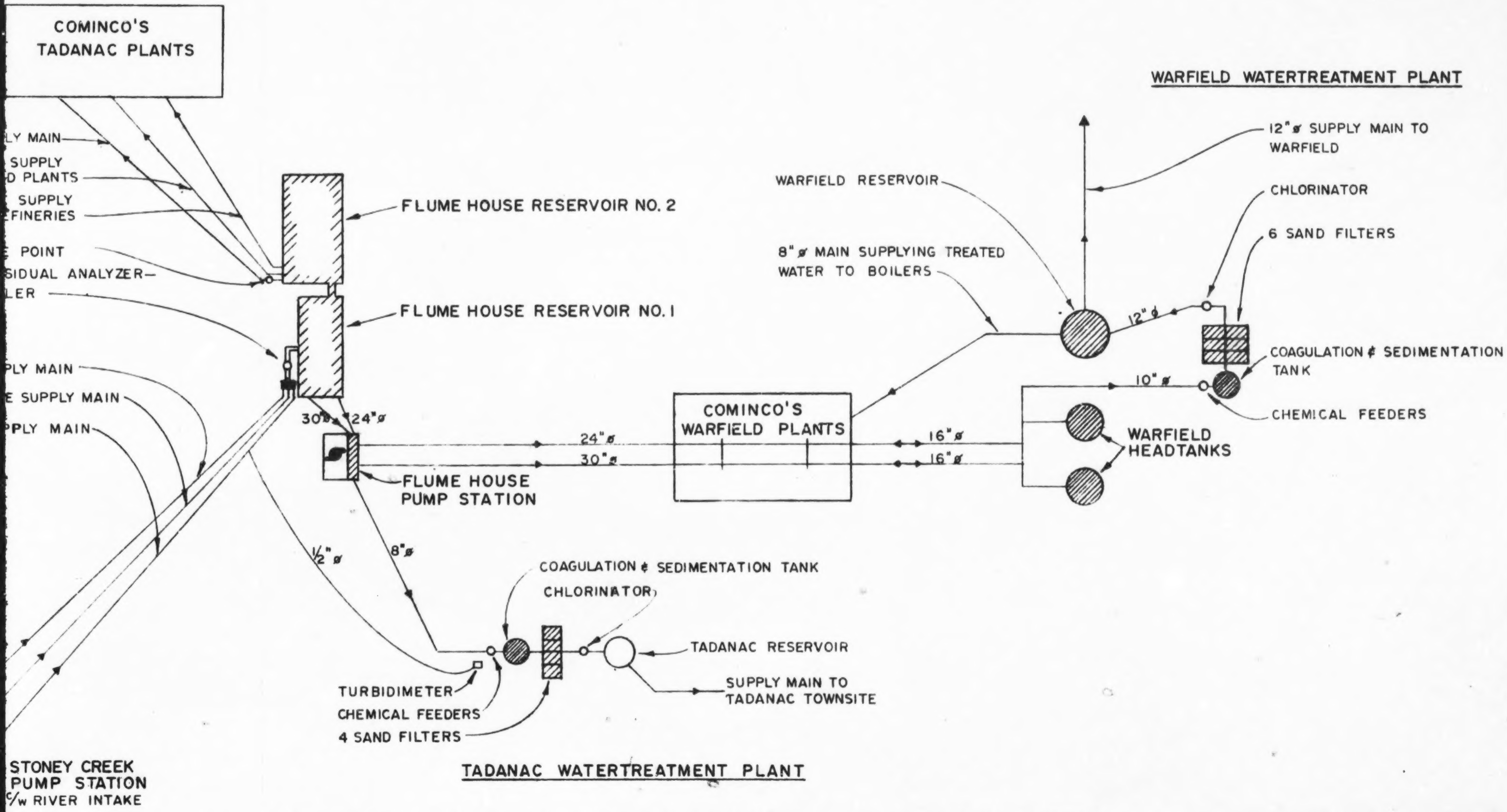

OASIS WATERWORKS DISTRICT
MURPHY CREEK DAMSITE
DISTRICT OF TADANAC
RIVERVALE
COMINCO
CITY OF TRAIL
VILLAGE OF WARFIELD
McGAULEY CONCRETE
CUTILLO
GREEN GABLES
FRUITVALE WATERWORKS DISTRICT
BEAVER FALLS WATERWORKS DISTRICT
VILLAGE OF MONTROSE
COLUMBIA GARDENS
TRAIL
Warfield
Montrose
COLUMBIA
MOUNTAINS
FOREST
PROVINCIAL
RIVER
Lookout Mountain
Casino
SCALE IN MILES
0

EXISTING WATERWORKS SYSTEMS

FIGURE [illegible]

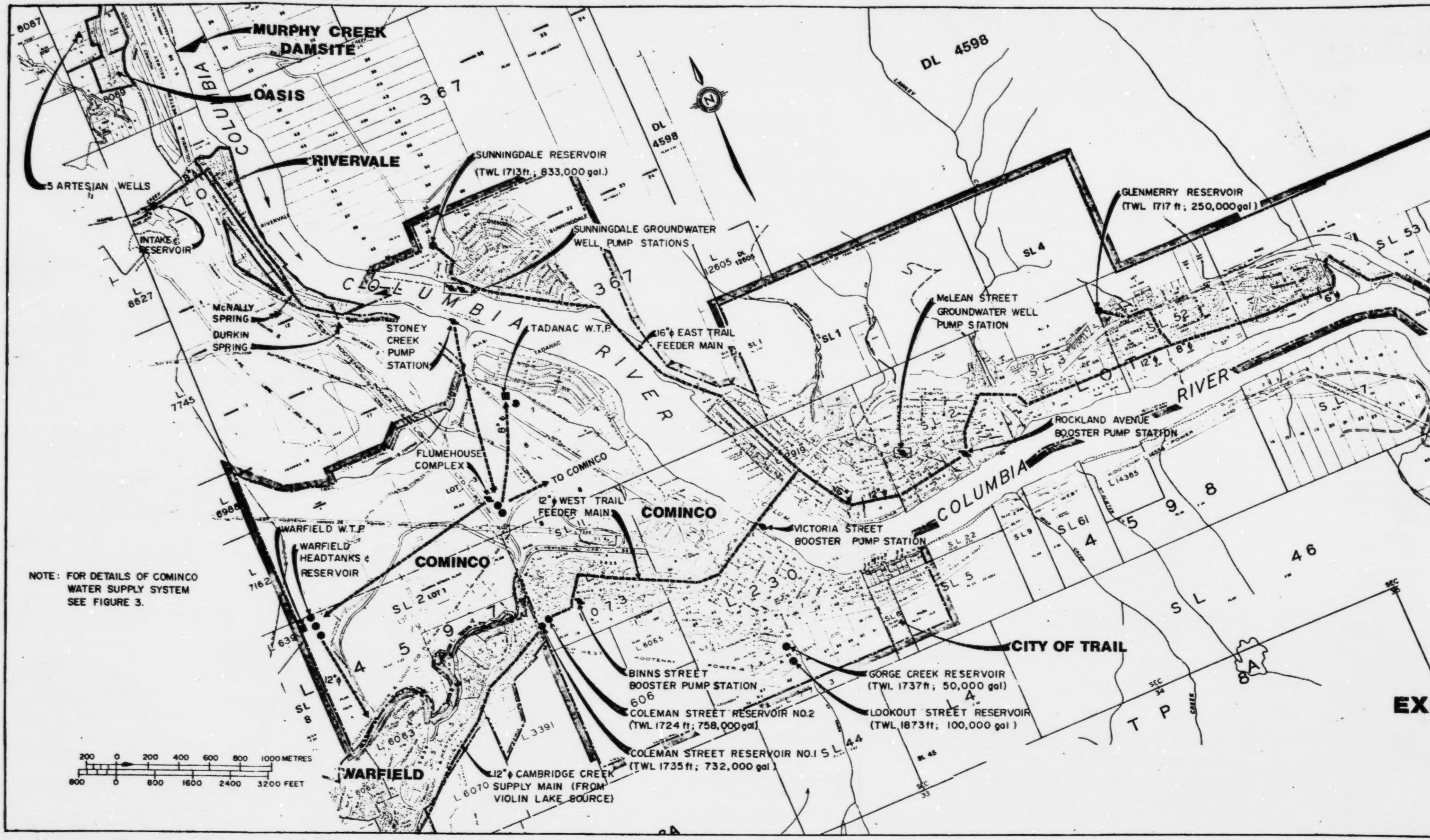

COMINCO'S TADANAC PLANTS
42" ø STEEL SUPPLY MAIN
24" ø WOODSTAVE SUPPLY MAIN TO ACID PLANTS
12" ø WOODSTAVE SUPPLY MAIN TO REFINERIES
CHLORINE SAMPLE POINT
CHLORINATOR-RESIDUAL ANALYZER-AUTO CONTROLLER
FLUME HOUSE RESERVOIR NO. 2
FLUME HOUSE RESERVOIR NO. 1
36" ø STEEL SUPPLY MAIN
30" ø WOODSTAVE SUPPLY MAIN
30" ø STEEL SUPPLY MAIN
30"ø
24"ø
FLUME HOUSE PUMP STATION
24"ø
30"ø
COMINCO'S WARFIELD PLANTS
16"ø
16"ø
WARFIELD RESERVOIR
8" ø MAIN SUPPLYING TREATED WATER TO BOILERS
1/2"ø
8"ø
COAGULATION & SEDIMENTATION TANK
CHLORINATOR
TADANAC RESERVOIR
SUPPLY MAIN TO TADANAC TOWNSITE
TURBIDIMETER
CHEMICAL FEEDERS
4 SAND FILTERS
TADANAC WATERTREATMENT PLANT
COLUMBIA RIVER
STONEY CREEK PUMP STATION c/w RIVER INTAKE

SCHEMATIC OF COMINCO - TADANAC - WARFIELD WATER SUPPLY SYSTE


COMINCO'S TADANAC PLANTS
LY MAIN
SUPPLY
D PLANTS
SUPPLY
FINERIES
E POINT
SIDUAL ANALYZER
LER
PLY MAIN
E SUPPLY MAIN
PPLY MAIN
FLUME HOUSE RESERVOIR NO. 2
FLUME HOUSE RESERVOIR NO. 1
30"ø
24"ø
FLUME HOUSE PUMP STATION
24"ø
30"ø
COMINCO'S WARFIELD PLANTS
16"ø
16"ø
WARFIELD WATERTREATMENT PLANT
WARFIELD RESERVOIR
8"ø MAIN SUPPLYING TREATED WATER TO BOILERS
12"ø SUPPLY MAIN TO WARFIELD
CHLORINATOR
6 SAND FILTERS
12"ø
COAGULATION & SEDIMENTATION TANK
10"ø
CHEMICAL FEEDERS
WARFIELD HEADTANKS
1/2"ø
8"ø
COAGULATION & SEDIMENTATION TANK
CHLORINATOR
TADANAC RESERVOIR
SUPPLY MAIN TO TADANAC TOWNSITE
TURBIDIMETER
CHEMICAL FEEDERS
4 SAND FILTERS
TADANAC WATERTREATMENT PLANT
STONEY CREEK PUMP STATION C/W RIVER INTAKE

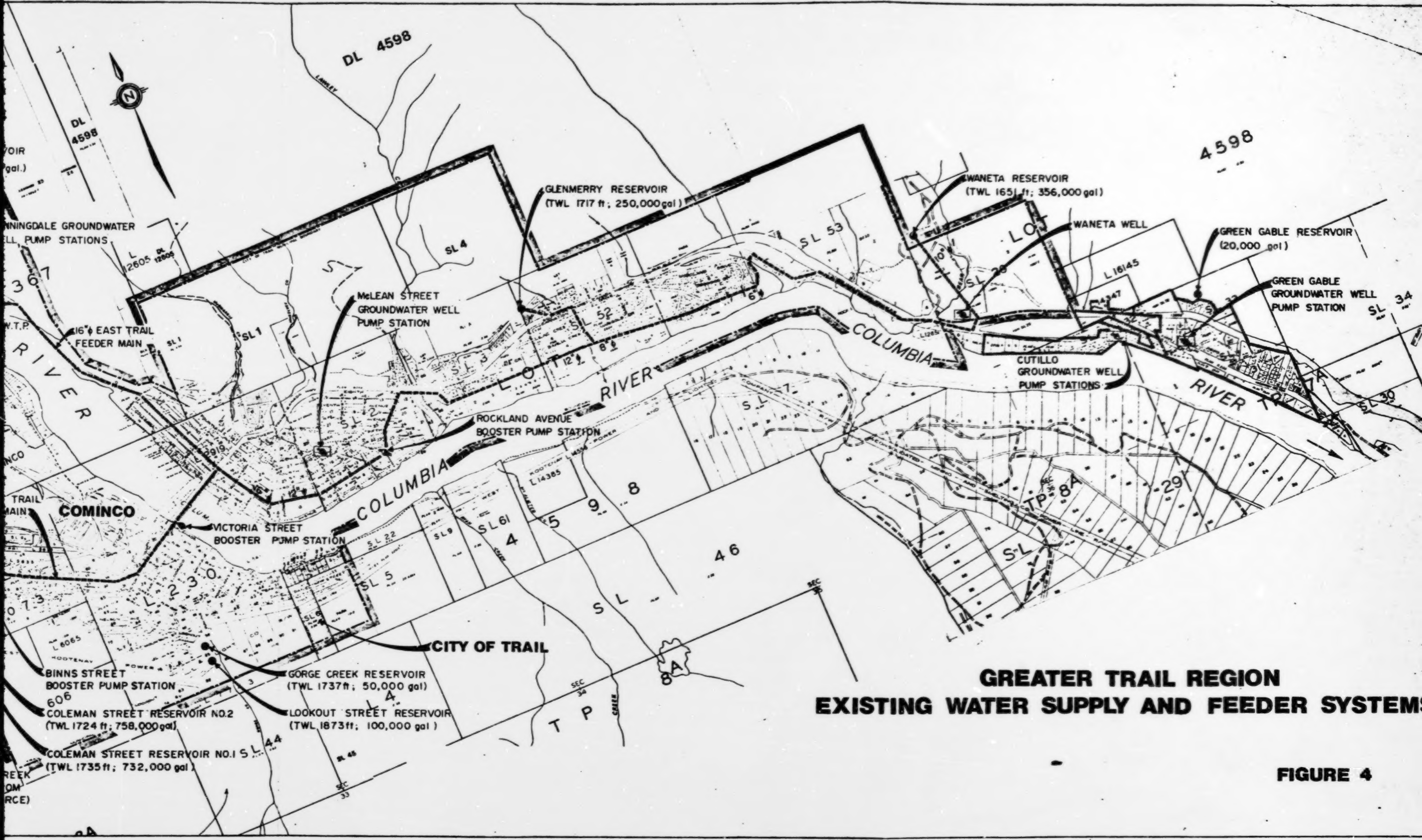
SCHEMATIC OF COMINCO - TADANAC - WARFIELD WATER SUPPLY SYSTEM

FIGURE 3



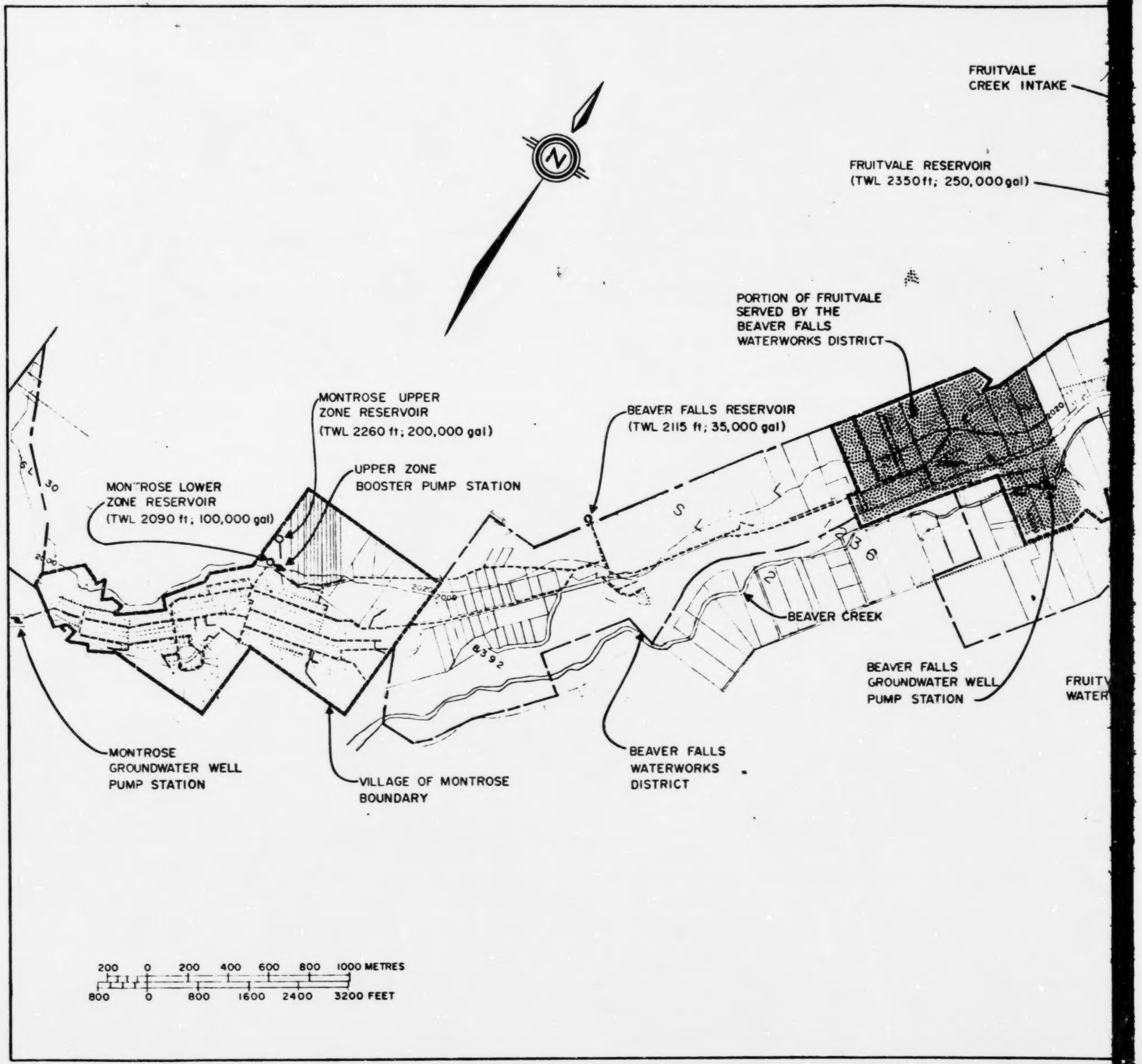
MURPHY CREEK DAMSITE
OASIS
RIVERVALE
5 ARTESIAN WELLS
INTAKE RESERVOIR
COLUMBIA
McNALLY SPRING
DURKIN SPRING
STONEY CREEK PUMP STATION
SUNNINGDALE RESERVOIR (TWL 1713ft.; 833,000 gal.)
SUNNINGDALE GROUNDWATER WELL PUMP STATIONS
TADANAC W.T.P.
16"ϕ EAST TRAIL FEEDER MAIN
COLUMBIA RIVER
FLUMEHOUSE COMPLEX
TO COMINCO
12"ϕ WEST TRAIL FEEDER MAIN
COMINCO
WARFIELD W.T.P.
WARFIELD HEADTANKS & RESERVOIR
COMINCO
WARFIELD
12" CAMBRIDGE CREEK SUPPLY MAIN (FROM VIOLIN LAKE SOURCE)
BINNS STREET BOOSTER PUMP STATION
COLEMAN STREET RESERVOIR NO.2 (TWL 1724 ft; 758,000 gal)
COLEMAN STREET RESERVOIR NO.1 (TWL 1735 ft; 732,000 gal)
VICTORIA STREET BOOSTER PUMP STATION
CITY OF TRAIL
GORGE CREEK RESERVOIR (TWL 1737 ft; 50,000 gal)
LOOKOUT STREET RESERVOIR (TWL 1873 ft; 100,000 gal)
McLEAN STREET GROUNDWATER WELL PUMP STATION
ROCKLAND AVENUE BOOSTER PUMP STATION
GLENMERRY RESERVOIR (TWL 1717 ft; 250,000 gal)
COLUMBIA RIVER
DL 4598
367
L 230
1073
4597
4598
SL 46
TP 8A
N
200 0 200 400 600 800 1000 METRES
800 0 800 1600 2400 3200 FEET
EX

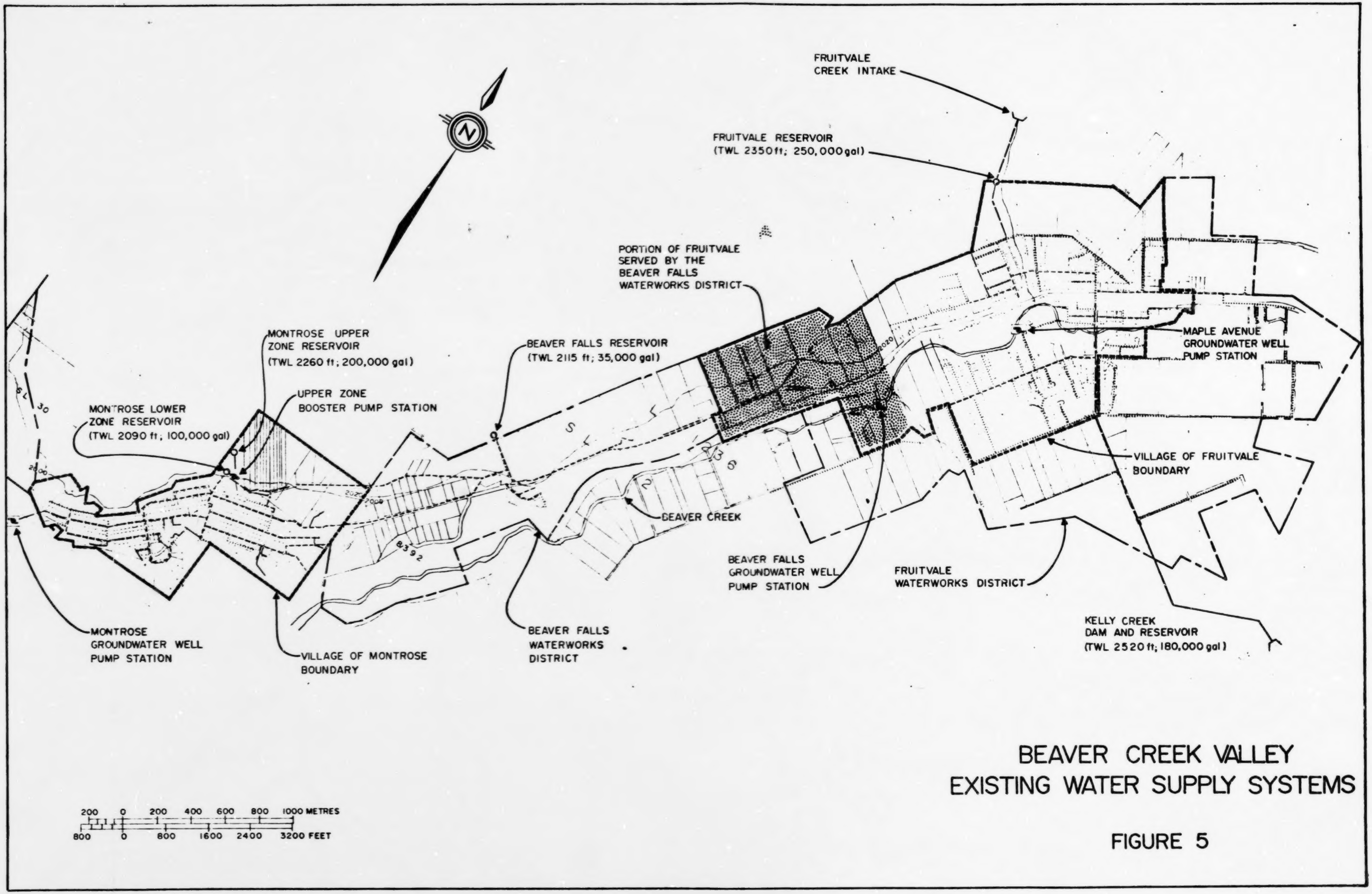
NOTE: FOR DETAILS OF COMINCO WATER SUPPLY SYSTEM SEE FIGURE 3.


DL 4598
DL 4598
4598
VOIR
gal.)
NNINGDALE GROUNDWATER
ELL PUMP STATIONS
L 12605
DL 12609
367
W.T.P.
16" φ EAST TRAIL FEEDER MAIN
COLU RIVER
SL 1
SL 1
SL 4
McLEAN STREET GROUNDWATER WELL PUMP STATION
GLENMERRY RESERVOIR (TWL 1717 ft; 250,000 gal)
SL 53
WANETA RESERVOIR (TWL 1651 ft; 356,000 gal)
WANETA WELL
LOT
SL 28
L 16145
GREEN GABLE RESERVOIR (20,000 gal)
GREEN GABLE GROUNDWATER WELL PUMP STATION
SL 34
SL 52
SL 3
LOT 12
COLUMBIA
CUTILLO GROUNDWATER WELL PUMP STATIONS
RIVER
RIVER
SL 30
SL 2
ROCKLAND AVENUE BOOSTER PUMP STATION
SL 7
L 2919
COLUMBIA
L 14385
9
8
TP 8A
29
TRAIL MAIN
COMINCO
VICTORIA STREET BOOSTER PUMP STATION
SL 22
SL 9
SL 61
4
5
46
SL
L 230
073
SL 5
SL 6
SL
SEC 35
CITY OF TRAIL
L 6065
BINNS STREET BOOSTER PUMP STATION
606
COLEMAN STREET RESERVOIR NO.2 (TWL 1724 ft; 758,000 gal)
COLEMAN STREET RESERVOIR NO.1 (TWL 1735 ft; 732,000 gal)
GORGE CREEK RESERVOIR (TWL 1737 ft; 50,000 gal)
LOOKOUT STREET RESERVOIR (TWL 1873 ft; 100,000 gal)
L 4
SEC 34
TP
8A
SL 44
SL 45
SEC 33
REEK
OM
RCE)
ST

GREATER TRAIL REGION
EXISTING WATER SUPPLY AND FEEDER SYSTEMS

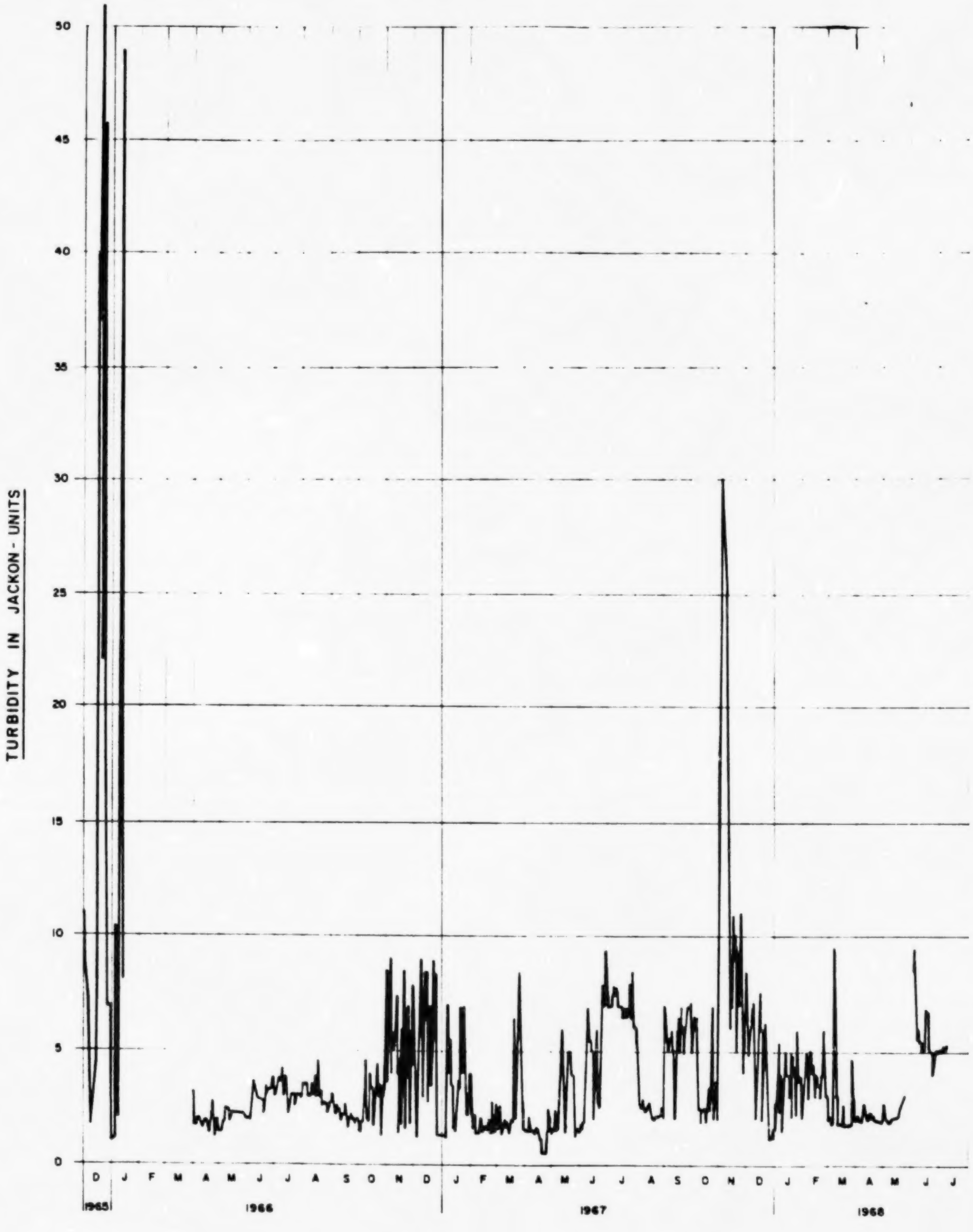
FIGURE 4


N
FRUITVALE CREEK INTAKE
FRUITVALE RESERVOIR (TWL 2350 ft; 250,000 gal)
PORTION OF FRUITVALE SERVED BY THE BEAVER FALLS WATERWORKS DISTRICT
MONTROSE UPPER ZONE RESERVOIR (TWL 2260 ft; 200,000 gal)
BEAVER FALLS RESERVOIR (TWL 2115 ft; 35,000 gal)
UPPER ZONE BOOSTER PUMP STATION
MONTROSE LOWER ZONE RESERVOIR (TWL 2090 ft; 100,000 gal)
BEAVER CREEK
BEAVER FALLS GROUNDWATER WELL PUMP STATION
FRUITV
WATER
MONTROSE GROUNDWATER WELL PUMP STATION
VILLAGE OF MONTROSE BOUNDARY
BEAVER FALLS WATERWORKS DISTRICT
200 0 200 400 600 800 1000 METRES
800 0 800 1600 2400 3200 FEET


FRUITVALE CREEK INTAKE
FRUITVALE RESERVOIR (TWL 2350 ft; 250,000 gal)
PORTION OF FRUITVALE SERVED BY THE BEAVER FALLS WATERWORKS DISTRICT
MAPLE AVENUE GROUNDWATER WELL PUMP STATION
MONTROSE UPPER ZONE RESERVOIR (TWL 2260 ft; 200,000 gal)
BEAVER FALLS RESERVOIR (TWL 2115 ft; 35,000 gal)
UPPER ZONE BOOSTER PUMP STATION
MONTROSE LOWER ZONE RESERVOIR (TWL 2090 ft; 100,000 gal)
VILLAGE OF FRUITVALE BOUNDARY
BEAVER CREEK
BEAVER FALLS GROUNDWATER WELL PUMP STATION
FRUITVALE WATERWORKS DISTRICT
KELLY CREEK DAM AND RESERVOIR (TWL 2520 ft; 180,000 gal)
MONTROSE GROUNDWATER WELL PUMP STATION
VILLAGE OF MONTROSE BOUNDARY
BEAVER FALLS WATERWORKS DISTRICT
N
200 0 200 400 600 800 1000 METRES
800 0 800 1600 2400 3200 FEET

BEAVER CREEK VALLEY
EXISTING WATER SUPPLY SYSTEMS

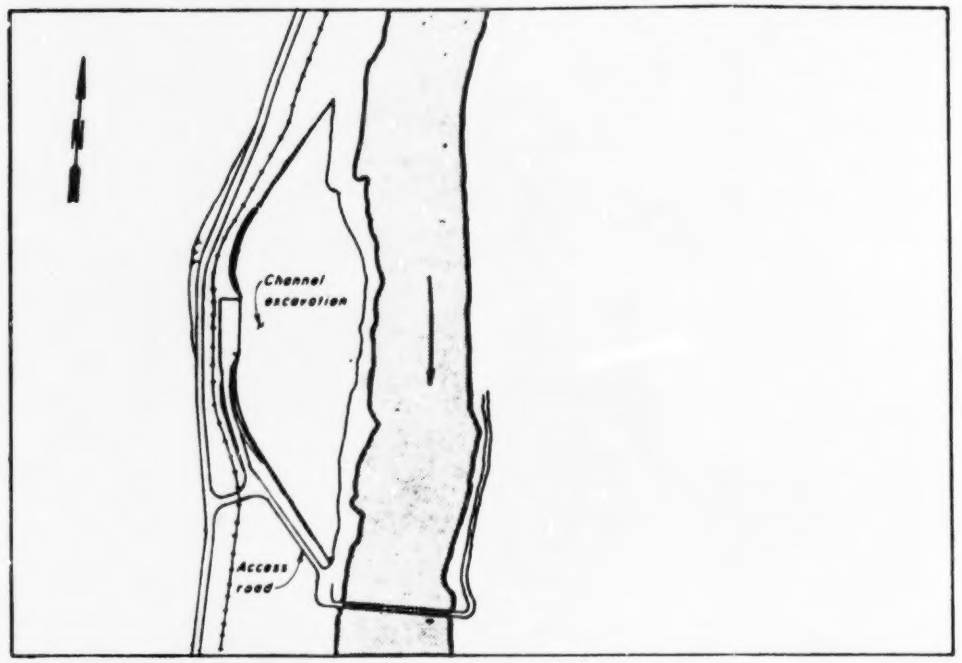
FIGURE 5



COLUMBIA RIVER TURBIDITY
(MONITORED AT TADANAC WTP)

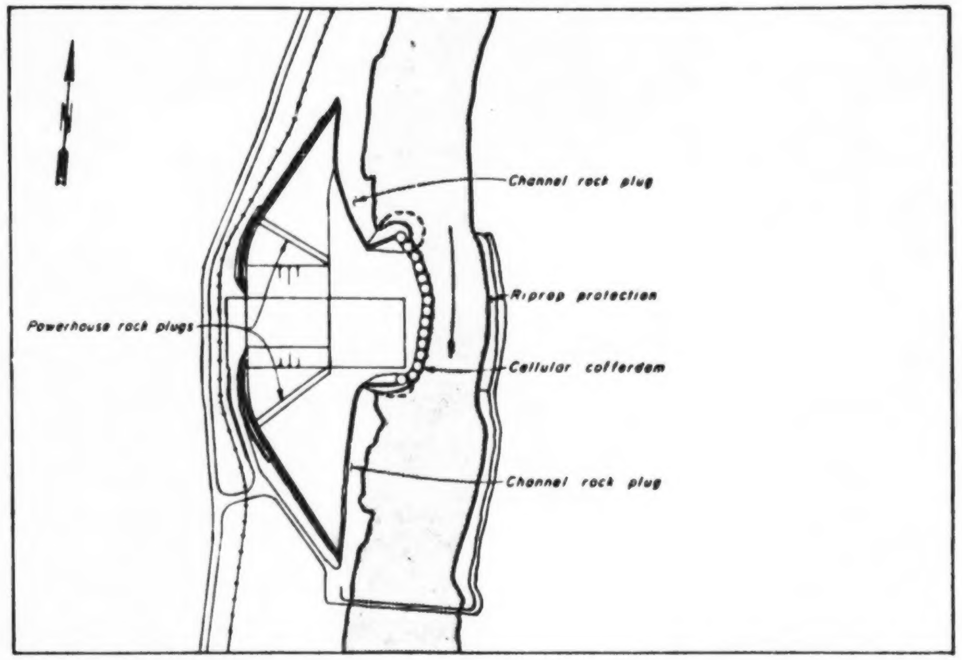
FROM WEST KOOTENAY
HEALTH UNIT RECORDS

FIGURE 6


N
Channel excavation
Access road

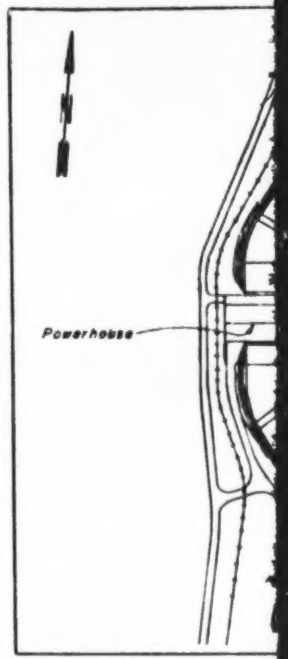
PHASE A

-RELOCATE TRANSMISSION LINES, ROAD, RAIL
-BUILD SITE ACCESS ROADS, TEMPORARY BRIDGE AND PREPARE WORK AREAS
-EXCAVATE CHANNEL TO EL. 412


N
Channel rock plug
Riprap protection
Powerhouse rock plugs
Cellular cofferdam
Channel rock plug

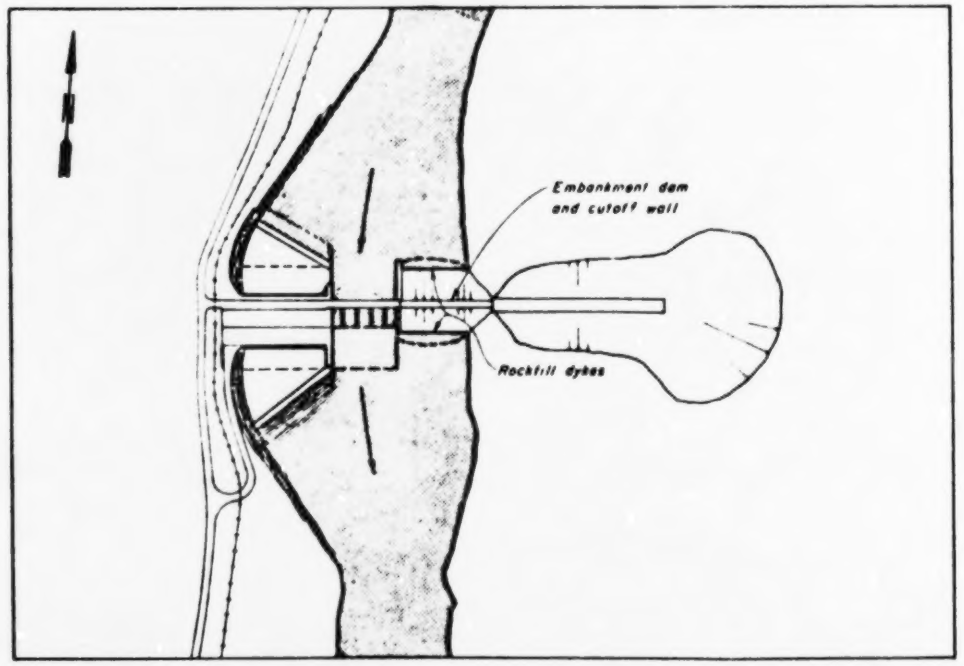
PHASE B (FIRST STAGE DIVERSION)

WIDEN RIVER CHANNEL AND PLACE LEFT BANK RIPRAP PROTECTION
-CONSTRUCT CELLULAR COFFERDAM
-EXCAVATE SPILLWAY AND POWERHOUSE
-COMPLETE CHANNEL EXCAVATION EXCEPT FOR CHANNEL AND POWERHOUSE ROCK PLUGS


N
Powerhouse

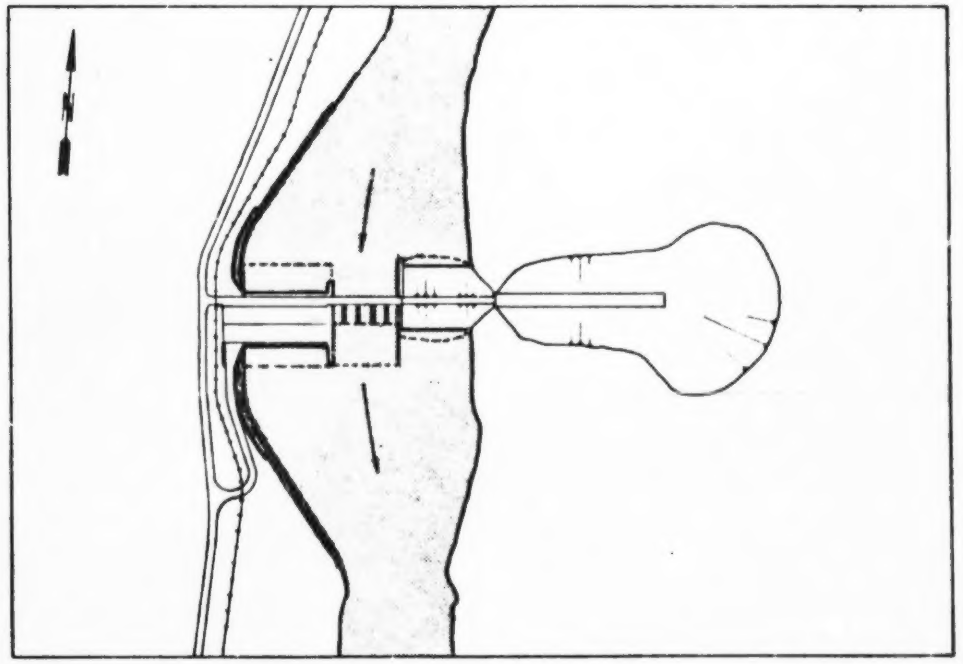
PHASE C

-CONSTRUCT POWERHOUSE AND SPILLWAY S
-INSTALL SPILLWAY GATES
-EXCAVATE LEFT BANK OVERBURDEN MATER
-CONSTRUCT LEFT BANK CUTOFF WALL


N
Embankment dam and cutoff wall
Rockfill dykes

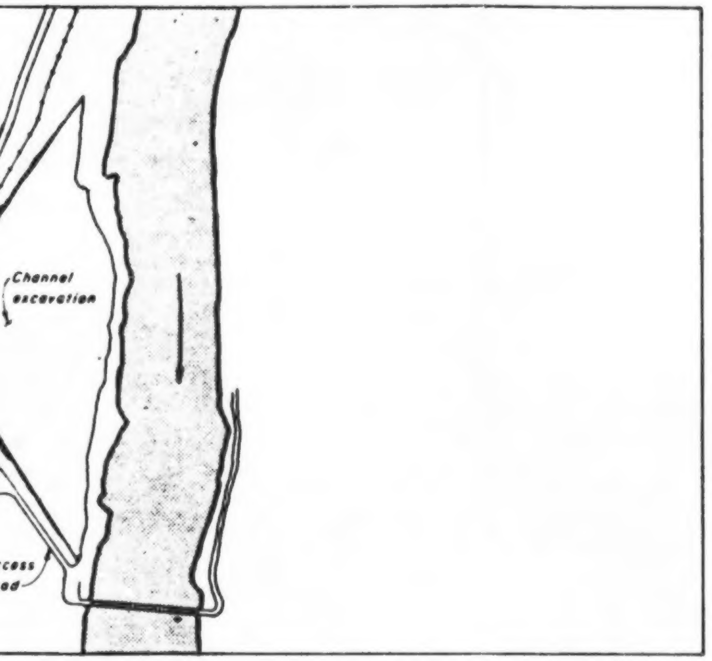
PHASE D (SECOND STAGE DIVERSION)

-REMOVE CELLULAR COFFERDAM AND CHANNEL ROCK PLUGS
-DIVERT RIVER
-CONSTRUCT THROUGH SPILLWAY ROCKFILL DYKES AND PLACE GRANULAR FILL
-COMPLETE CUTOFF WALL
-COMPLETE EMBANKMENT DAM CONSTRUCTION
-COMPLETE POWERHOUSE
-REMOVE TEMPORARY BRIDGE

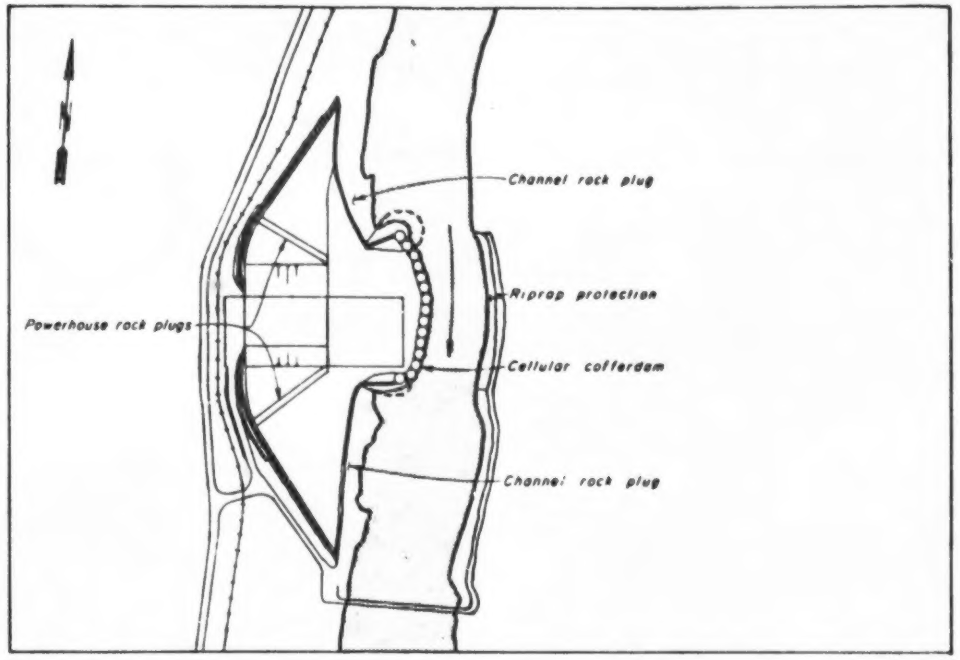


PHASE E

-REMOVE POWERHOUSE ROCK PLUG COFFERDAMS
-FILL RESERVOIR

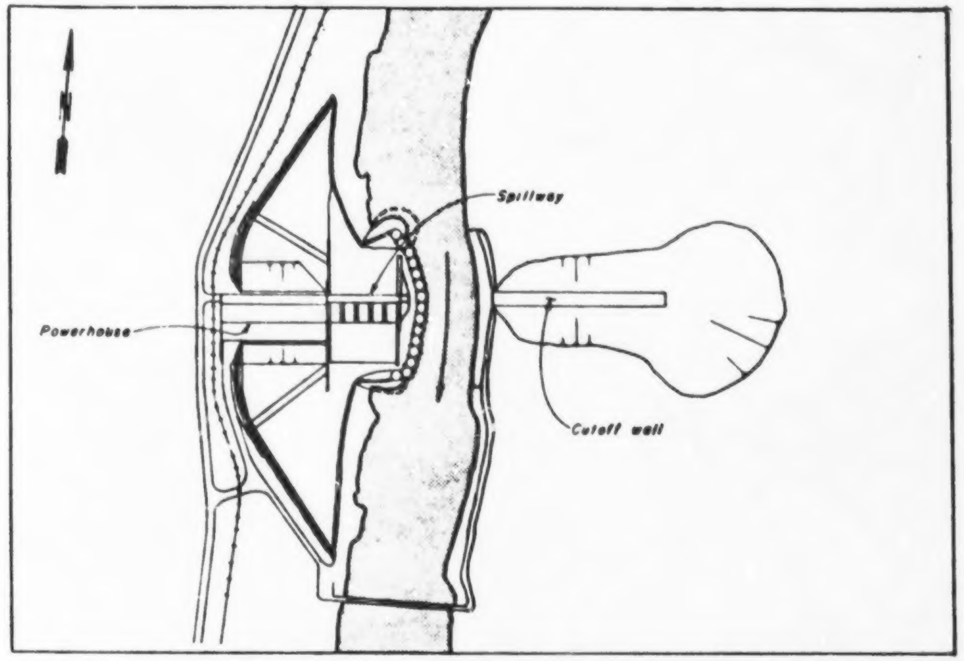

Channel excavation
cess
ad

, RAIL
Y BRIDGE AND PREPARE WORK AREAS


Channel rock plug
Riprap protection
Powerhouse rock plugs
Cellular cofferdam
Channel rock plug

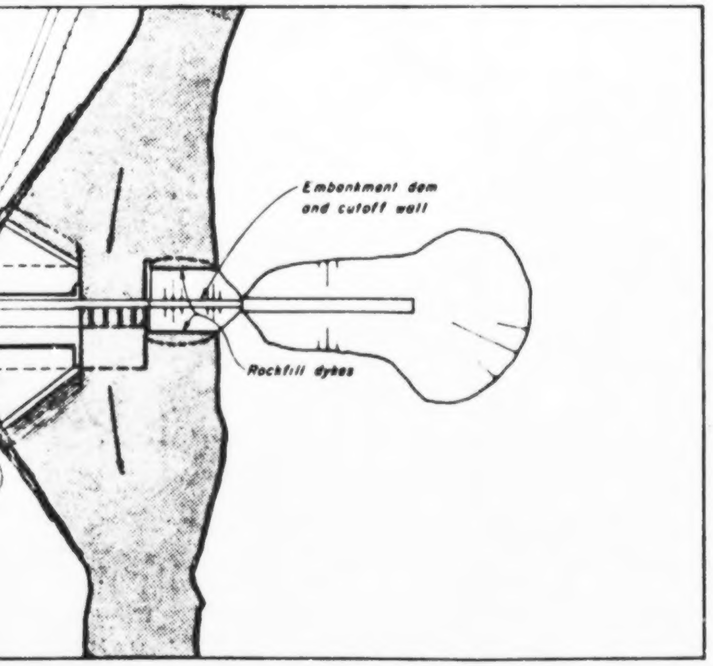
PHASE B (FIRST STAGE DIVERSION)

-WIDEN RIVER CHANNEL AND PLACE LEFT BANK RIPRAP PROTECTION
-CONSTRUCT CELLULAR COFFERDAM
-EXCAVATE SPILLWAY AND POWERHOUSE
-COMPLETE CHANNEL EXCAVATION EXCEPT FOR CHANNEL AND POWERHOUSE ROCK PLUGS


Spillway
Powerhouse
Cutoff wall

PHASE C

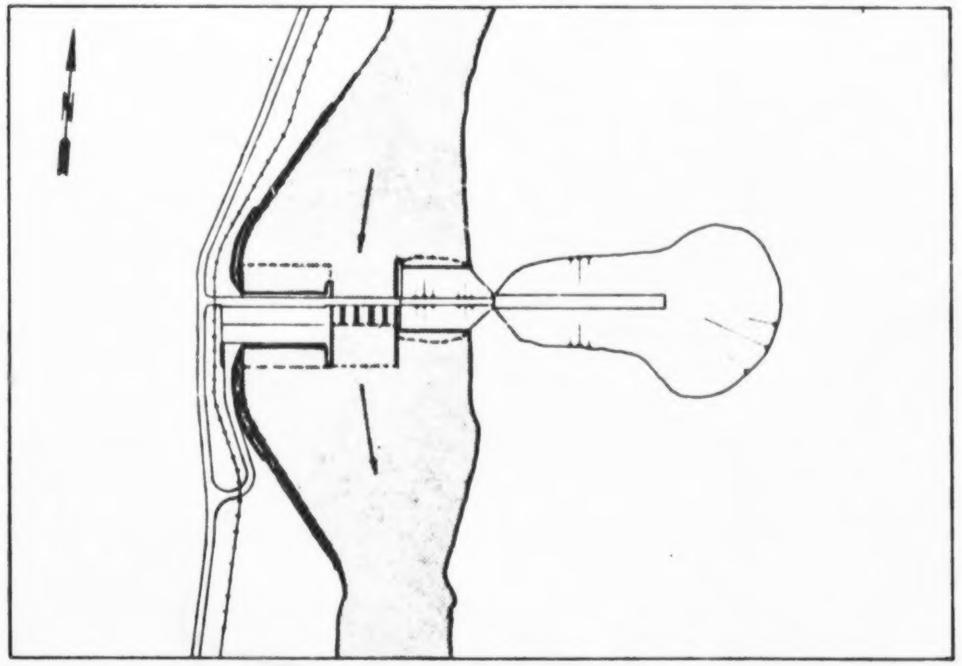
-CONSTRUCT POWERHOUSE AND SPILLWAY STRUCTURES
-INSTALL SPILLWAY GATES
-EXCAVATE LEFT BANK OVERBURDEN MATERIAL
-CONSTRUCT LEFT BANK CUTOFF WALL


Embankment dam and cutoff wall
Rockfill dykes

NNEL ROCK PLUGS

LL DYKES AND PLACE GRANULAR FILL

TION



PHASE E

-REMOVE POWERHOUSE ROCK PLUG COFFERDAMS
-FILL RESERVOIR

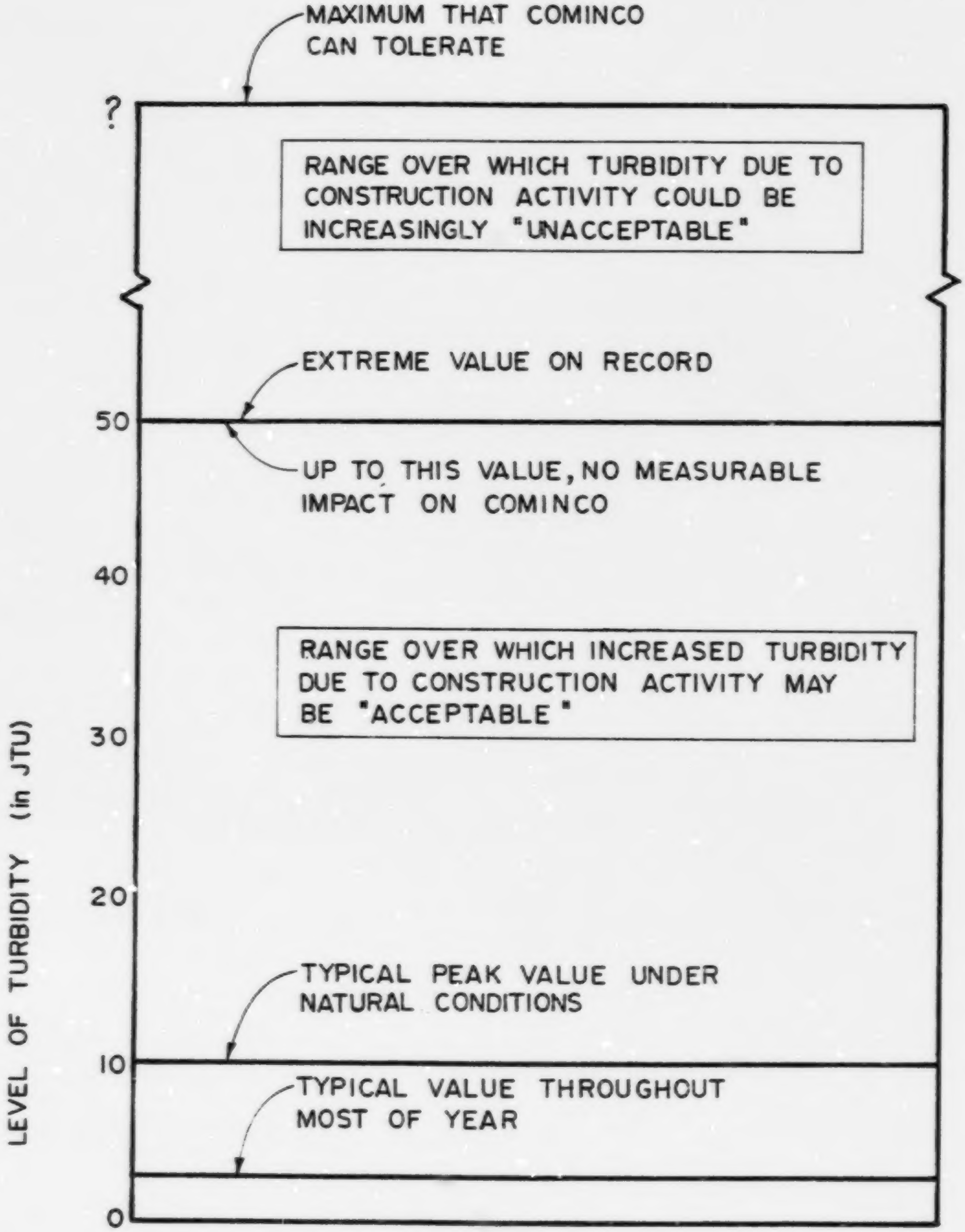
Scale: NTS

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COLUMBIA RIVER - MURPHY CREEK PROJECT

CONSTRUCTION AND RIVER DIVERSION SEQUENCE

DATE NOV 1982
FIG. 7
R
DWN P. K.
DWG No 218-C14-U423



RELATIONSHIP BETWEEN TURBIDITY AND CONSTRUCTION ACTIVITY

FIGURE 8

POOR

QUALITY

ORIGINAL